JOURNAL *of* THE SOCIETY OF CHEMICAL INDUSTRY

CHEMISTRY & INDUSTRY

Official Organ of the Institution of Chemical Engineers, of the Coke Oven Managers' Association, and of the Federal Council for Chemistry

which consists of Representatives from

The Chemical Society, the Society of Chemical Industry, the Association of British Chemical Manufacturers, the Institute of Chemistry, the Society of Public Analysts, the Faraday Society, the Institute of Brewing, the Society of Dyers and Colourists, the Society of Glass Technology, the Iron and Steel Institute, the Ceramic Society, the Institution of Gas Engineers, the Society of Leather Trade Chemists, the Royal Photographic Society, the Mineralogical Society, the Biochemical Society, the Oil and Colour Chemists' Association, the Institute of Metals and the Royal Agricultural Society.

VOL. 52 | LONDON, APRIL 21, 1933 | NO. 16

EDITORIAL

Imperial Chemical Industries, Ltd.

THE annual general meeting of this great company is perhaps not so great or so spectacular an occasion as many others if we regard it as merely a time for a few hours of oratory, but if we treat it as providing a summary of a year's work we see it in a truer perspective and recognize that the efforts of this important manufacturing concern count as a vital factor in our national progress and deserve careful study. Imperial Chemical Industries, Ltd. is a company that by reason of its size, the variety of its products, its prosperity, and its close contact with the scientific world, cannot help setting an example that will be watched by scores of smaller companies here and elsewhere. We are glad to think that its example should not only be watched but also followed and that the high standard which it has set is one that will commend itself to the great majority of reasonable and large-minded people. We have already commented on its prudence and conservatism in matters of finance and now propose to refer to some other aspects of its many activities. In its relations with the Government it has always had a broad and patriotic outlook and we are glad that Sir Harry McGowan in his speech mentioned the assistance that his colleague Lord Weir was able to render the Government during the Ottawa conference and the services of Mr. Woolcock there recognized, as our readers know, by his inclusion in the Honours List, as a Companion of the Order of St. Michael and St. George. In its attitude towards research the I.C.I. has a fine record; its research laboratories have been kept in full commission during the year and are constantly engaged in examining processes and inventions as well as the possibilities of new products. The annual expenditure of the I.C.I. in this country on technical research exceeds £[illegible]00,000, a sum of money that is really notable. It is interesting to find that so far as the manufacture of heavy chemicals is concerned, including nitrogenous fertilizers and the heavy organic products, this country is now self-supporting. Sir Harry McGowan tells us that the rate of new discovery increases rather than slackens and that the influence of chemical products and technique on agriculture, on the transport and conservation of foodstuffs, on textiles, and still more recently on building products, is sufficiently great to assure the I.C.I. of a progressive forward policy within its legitimate field. We are glad to notice the interest the I.C.I. takes in the housing question for it is one that affects us all. If by the use of new methods and new products it becomes possible to build houses or flats that can be let at rents that the inhabitants can afford to pay without starving themselves for food, a great advance will be made and already steps are being taken in this direction, but the need for more and cheaper dwellings is still a very pressing one and we are glad that there is a hope of greater progress in this direction. Among the many items of research receiving attention from the I.C.I. is that on the hydrogenation of coal, work on which is being continued with marked success. Lord Reading had some pertinent remarks to make on this at the annual meeting and he asks for Government assistance by the allowance of a greater deduction for wear and tear and depreciation of plant before income tax is levied. In the old days chemical plant was worn out, after many long years of use, and a low percentage of depreciation was reasonable. Things are different now; research proceeds at so rapid a rate that after only a few years' use the plant may become expensive and wasteful because far cheaper ones are on the market. We are obliged to replace our motor-cars, after about five years' use, not because they are worn out, but because newer cars are now made that will run many more miles to the gallon. We trust that the Government will be not only sympathetic—it is sure to be this—but also helpful in this connexion. The last item that we have space to refer to among the praiseworthy activities of the company is the satisfactory relationship between the company as a legal entity and those persons who are in receipt of wages and salaries from it, and constitute in another way the living organism that makes products and profits and builds up reserves and developments and steadily grows from year to year. We are glad to note that there is a happy feeling pervading the company from whichever aspect it is regarded. In this, as in the other respects we have mentioned, the company has set a good example. We trust that as it continues to prosper it will continue to pursue the policy it now adopts and will from time to time be able to set up new standards so that it will always be in the forefront of progress.

A DECADE OF APPLIED X-RAY RESEARCH

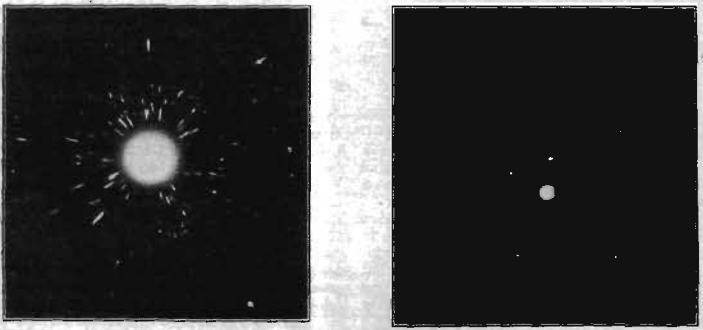
GRASSELLI MEDAL ADDRESS

By PROF. GEORGE L. CLARK

(*Concluded from p. 325*)

Problems in the annealing of sheet metals.—Several years ago the first series of pinhole diffraction patterns was made for silicon steel strips with varying magnetic hysteresis loss. It was found that if the grain boundaries were not unduly thickened by over-heating in the anneal furnace, the loss may be calculated empirically from the number and size of diffraction spots on a given area of the various patterns. Occasionally some strips may be unusually brittle and have unaccountably high loss. *In every case an X-ray examination proves that the large single grains have an extraordinary orientation of crystallographic planes with respect to the surface of* the sheet due to an uncontrolled factor in the rolling or annealing operation. More important from the standpoint of magnetic properties and grain size is grain perfection, that is, freedom from all strain. This has been amply demonstrated in recent extensive experiments in this laboratory. The *X*-ray pattern is the only guide to establishment of the correct rolling and heat treatment which will ensure grain perfection. Fig. 9A shows the pattern of supposedly highest quality silicon steel commercially produced in 1932, while Fig. 9B shows the result of remarkably simple technique derived with the help of *X*-ray control from the same raw material. *The magnetic properties of the latter,* as well as its ductility, are markedly superior. Scientific control of production is easily possible by regulation of the silicon content, percentage cold reduction without intermediate anneal, time and temperature of anneal, extent of a further pinch pass, and final heat treatment. New mills with small rolls enable cold-rolling of the silicon steel to be successfully done for the first time.

Since silicon steel represents large grain aggregates, the *X*-ray diffraction patterns are characterized by a random peppering of spots rather than definite rings. Hence it would appear to be impossible to discover by ordinary diffraction methods whether there is any tendency toward preferred orientation of these large grains throughout the sheet. *Recourse is then had to* the simple device of slowly moving a specimen in its own place across the pinhole by a suitable mechanical device during the exposure. The resulting pattern is an integration over a large number of grains instead of the few contained in only a certain area traversed by the *X*-ray beam in the stationary sample. If there is a preponderance of orientation in any one direction a definite concentration of spots will appear. The *indications are that some such preferred orientation may* actually be beneficial to certain magnetic properties. *Further studies will lead undoubtedly to the production* and selection of steel for electrical purposes with such lowered magnetic loss and superior permeability that the size of electric machinery for a given load may be reduced appreciably.



A FIG. 9 B

A. *Structure of supposed best grade of silicon electric steel now on market, showing grain distortion.* B. *Very high-grade silicon steel showing entire absence of grain distortion and greatly superior magnetic properties*

Another problem of considerable commercial importance is the annealing of sheet copper and brass. A specimen was recently submitted for examination which had failed in the forming of an automobile radiator, although annealing of the sheet had been very carefully carried out. The sheet had undergone recrystallization during the annealing treatment but the recrystallization structure showed a nearly perfect new orientation of *grains with the cube faces parallel to the rolling plane.* For satisfactory forming a random orientation of grains is essential, as indicated by a diffraction pattern with peppering of spots or uniformly intense diffraction rings, and yet this recrystallized sample indicated that the sheet was practically a single crystal. A further remarkable fact is that this structure persisted clear to the melting point. This is but a single example of a large

number of investigations of the cause of failure of annealed sheets.

For low carbon sheet steel two series of patterns are reproduced. Fig. 10 is for a constant annealing temperature of 1200° F. with successive reductions of 5, 15, 20, and 60%. At 1500° F. annealing gave a similar series. These patterns constitute a valuable standard. Relationships between reduction, temperature of annealing, and structure can best be shown by a three-dimensional diagram such as represented in Fig. 11, which shows readily how research on a given metal can lead to a thoroughly scientific method of heat treatment rather than an entirely empirical one. In this figure the variable which may be determined from *X*-ray data is grain size, though any other property might also serve. It proves that the final annealed structure of a sheet which has been cold-rolled to 90% reduction without intermediate anneals must be different from that of the sheet which has been rolled down in steps with intermediate anneals. Each of these in effect places the specimen back at 0% reduction. The diagram shows also that if very large grains are desired following a complete cold reduction, the specimen is annealed, giving the size characteristic for the reduction at the right of the diagram; then given a pinch pass or very small cold reduction, so that the conditions on the left of the diagram are realized; and then again heat-treated.

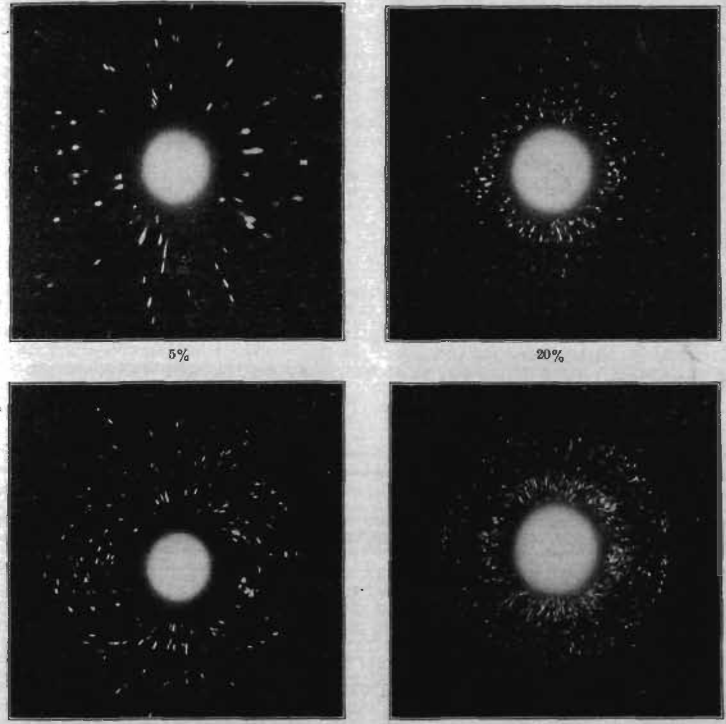


FIG. 10

Effect of annealing at 1200° F. on low carbon sheet with various reductions by cold work

A specification for watch springs.—Many difficulties arise in the manufacture and selection of dependable springs. *X*-ray diffraction results are remarkably illuminating and constitute a potential method of routine test as well as a research method of determining the correct manufacturing process. I have compared

the patterns for a fast-motion, too-brittle spring, a slow-motion, too-soft spring, and a standard spring which gave perfect satisfaction in a watch over many months. The chemical composition is the same; no difference may be detected between the three microscopically, and the steps in manufacture were supposedly identical. But in the *X*-ray patterns the brittle spring clearly shows residual preferred orientation (as do all the broken springs we have ever examined), the soft spring shows evidence of grain growth, and the standard spring entire absence of preferred orientation but no change in grain size. Evidently the temperatures and times of heat treatment must be so accurately determined that the preferred orientation is *just* removed.

A test for airplane propellers.—The duralumin airplane propeller is subjected probably to more intensive destructive forces than any other manufactured unit. Safety of life depends upon the soundness of the propeller and the resistance to fatigue failure. The *X*-ray examination of propellers, therefore, constitutes one of the greatest undertakings, particularly if the method is

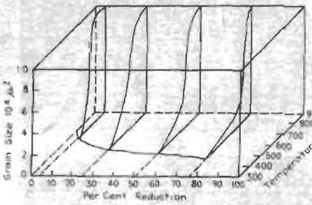


FIG. 11

Three-dimensional diagram illustrating control of annealing processes

to be made of practical testing value before installation and after given periods of use. Specimens cannot be cut from the propellers but reliance must be placed on a modified reflexion method. Of course a series of standard diffraction patterns can be made for specimens placed in fatigue machines and a rational comparison can thus be made for subsequent testing of propellers for actual use.

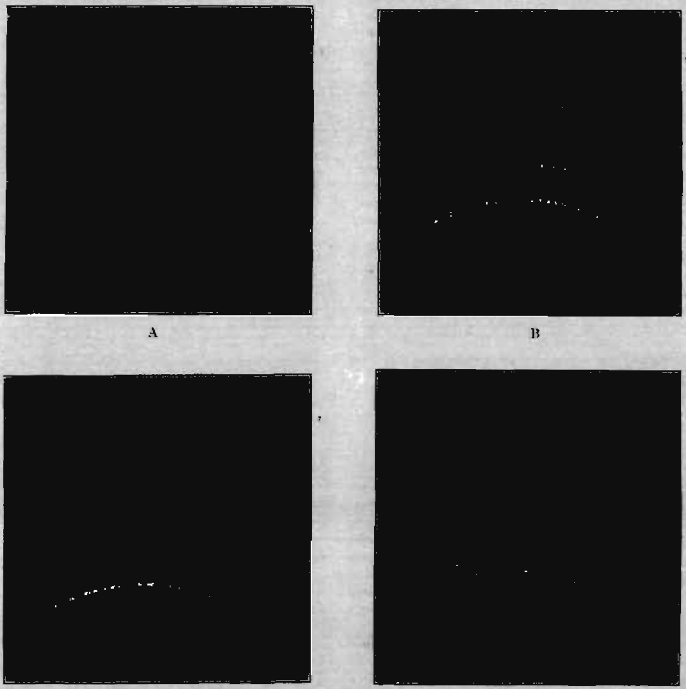
Back reflexion method.—The foregoing description of diffraction analysis of whole propellers is merely an indication that it has been possible for several years to examine large specimens which could not be satisfactorily cut up. The usual method has been to prepare very thin specimens through which an *X*-ray beam can be transmitted, but with the improvement in *X*-ray equipment, especially along the line of far greater radiation intensity, the various reflexion methods become increasingly more important. Recently some papers have appeared claiming credit for the discovery of the so-called back reflexion method. In this method the photographic film is placed round the pinhole and the diffracted rays coming directly back from the surface of the specimen are registered. The back reflexion method has been in use in the speaker's laboratory since 1924 and a full description was given, together with the method of analysis of patterns in 1929.

The inorganic crystal chemistry of storage batteries.—The chemical changes in the lead storage battery offer a fruitful field for diffraction analysis because of the uncertainty which remains to this day in spite of vigorous research efforts by every available means. The diffraction pattern shows exactly what crystalline compounds are present in the battery plate at any instant, the red tetragonal PbO, the yellow orthorhombic PbO, metallic lead, PbO_2, lead carbonate, addition agents, etc., the relative amounts by comparison of intensities of interferences, conditions of grain size, comparison of surface and interior and edge and centre of the active material after various cycles of charge and discharge. Radiation from a copper-target tube may be reflected from a given portion of a whole plate, or from a pellet extracted from the grid. Representative patterns for positive and negative plates are reproduced in Fig. 12. Numerous very important deductions have been possible upon the basis of preliminary experiments over a period of several years in this laboratory. This experience leads to the prediction that the eccentricities and unsatisfactory behaviour of batteries can be ascribed to definite causes upon the basis of diffraction analysis, and that scientific specification and construction must follow.

Ceramics.—There are many practical applications of the diffraction method to ceramic materials and as an indication of the fruitful results and of the possibilities for further usefulness, a few examples can be cited of researches carried out in the *X*-ray laboratory at the University of Illinois. In an investigation of the effect of heat on china clays, it was found that the chief crystalline constituent of the clay was kaolinite, whose lattice was destroyed upon dehydration. Mullite was formed at 950° C., and in Georgia clay free alumina was present from 950° to 1100° C. and cristobalite at temperatures above 1200° C. The *X*-ray method is of value in the detection of the various forms of silica in silica refractories, as found in a study of the zonal structure of silica brick from the roof of a basic open-hearth furnace: after use to the point of fusion in an open-hearth furnace the silica brick still retains quartz formation with increasing tendency towards cristobalite the higher the temperature. The identity of crystalline compounds present in sheet-steel enamels as opacifiers is easily determined: SnO_2 is the primary opacifying compound when it is used in any mixture; Sb_2O_5 when commercial Sb_2O_3 or sodium antimonate are the primary agents; sodium silico-fluoride, fluorspar, and cryolite aid in the development of opacity when used with the above compounds, although no diffraction lines for them appear. When used alone, however, they produce opacity, NaF from cryolite and CaF_2 from fluorspar. Interesting cases of solubility, dissociation, and oxidation are thus involved.

Mineralogy.—This has become one of the most important inorganic applications of diffraction analysis, particularly since the great steps forward in interpretation of silicate structures made by W. L. Bragg, Warren, Schiebold, Pauling, and others. There is no more eloquent example of the value of *X*-ray methods in

clearing up difficulties and establishing far-reaching correlations than in the comparison of diopside, with single chains of silicon–oxygen tetrahedra held together by shared oxygen atoms, amphibole with a double chain linked sidewise through another shared oxygen atom, and the extension of this same back-bone structure into a sheet in mica. An entire monograph upon this subject could be written since possibly two hundred minerals have already been examined. The interest lies not only in identification and classification (even to evaluation) of commercial ores, but in questions of chemical composition, and in geological questions of origin. In addition to unique analyses of crystal structures of asbestos minerals, mentioned in this chapter in connexion with silicates, Clark and Anderson made a study of eighty specimens from mines all over the world and found the diffraction patterns often so distinctive as to indicate the origin: the effects of acid and heat treatment were also characteristically depicted in patterns. Clark and Ally found that, for five chrome ores from different localities, the length of the edge of the unit cube ranged from 8·283 to 8·179, varying inversely with the Al_2O_3 content of the ore. The theoretical densities were calculated from the "average" molecular weights and X-ray data. Natural and synthesized spinels have been the subject of several investigations as regards identification and for their bearing on generalizations of crystal chemistry, and valuable data on these cubic crystals have been obtained by Clark, Ally, and Badger.



A B C D

Fig. 12

Typical patterns of commercial lead storage battery plates: A. Negative, interior; B. Negative, surface; C. Positive; D. Positive

Lattice dimensions (Å.U.) of synthetic spinels

Element	Aluminates	Chrominites	Ferrites
Zn	8·062 ± 0·001	8·296 ± 0·002	8·423 ± 0·001
M	8·086 ± 0·003	8·305 ± 0·001	8·366 ± 0·001
Fe	8·119 ± 0·002	8·344 ± 0·003	8·374 ± 0·003
Mn	8·271 ± 0·002	8·436 ± 0·001	8·457 ± 0·002

Special interest has been aroused in magnesium and zinc aluminates because of differences in lattice dimensions obtained in this laboratory and in that of Goldschmidt in Göttingen. The comparative data show how the method of synthesis may affect these values.

	Method I	Method II	Goldschmidt
$MgAl_2O_4$ ...	8·086 ± 0·003	8·066 ± 0·002	8·059 ± 0·006
$ZnAl_2O_4$ ...	8·062 ± 0·001	8·084 ± 0·002	8·093 ± 0·004

The measurement of the size and shape of grains.—It has been known for some time that *X*-ray diffraction interference becomes broader as the grain size of particles decreases below 10^{-5} to 10^{-6} cm. Numerous equations connecting grain size and width of the interferences at points of half-maximum intensity have been proposed. Brill has carried the matter farthest in showing that the shape of colloidal particles may be deduced. A series of standard curves has been plotted by Brill for b/r against the diffraction angle, χ, where b is the measured width of the interference and r is the radius of the samples. Interpolation gives the position on curves for various values of η R/r, where R is the radius of the camera and η is a number defined by

$$\eta = \frac{1}{3 \cdot 6\pi}\left[\mathrm{B}\cos\frac{\chi}{2} - \frac{1}{\mathrm{B}}\left(\pi\frac{r}{\mathrm{R}}\right)^2\cos^3\frac{\chi}{2}\right]$$

or for the cubic system,

$$\eta = \frac{\lambda}{4\pi a}\sqrt{\frac{(h/m_1)^2 + (k/m_2)^2 + (l/m_3)^2}{h^2 + k^2 + l^2}}$$

where h, k, l = the usual values and m = numbers indicating extension of the particles in the given direction. Thus even in a cubic crystal the shape of the particle influences the values of η. This has been of especial value in the estimation of the shape of carbon black specimens used as pigments, rubber fillers, etc., some of which seem to be uniformly extended in three dimensions, or nearly cubical or spherical, while others which produce only a single diffraction interference are evidently very tenuous and essentially unidimensional particles. The surface activities and covering power of paints are definite functions of the shape.

The technique of particle-size measurement has now been so much improved that there is little doubt of the validity and accuracy of the method. These equations have been carefully tested by Brill, using electrolytic nickel, the particle size of which can be exactly controlled by the sulphur content of the electrolyte. A very detailed analysis and test of the equations have been made by Clark and Zimmer on colloidal gold and silver sols from Heyden Fabrik, Dresden, Germany; nuclear gold sols by the method of Rinde; hydrous oxides; alcohol sols of alkaline earth carbonates, etc. In the case of the last substances which were postulated by Buzah to be dimethyl alkaline earth carbonates, patterns were obtained identical with those of the carbonates themselves, indicating that these are merely adsorption complexes. Fig. 13 shows patterns made in the writer's laboratory for hydrous cadmium hydroxide precipitated at 25°, 40°, and 100° C.; the effect of temperature on grain size is easily apparent.

Heretofore practically recourse has not been had to *X*-ray diffraction patterns for measuring or checking grain sizes in the microscopic range. Certain assumptions are always involved in microscopic study of size and number of grains per unit area or volume. Utilizing the same samples of brass with which the standard A.S.T.M. photomicrographs (Fig. 14) were prepared, Clark and Zimmer have found it possible to determine grain size from *X*-ray diffraction patterns when suitable experimental precautions have been taken. For grain

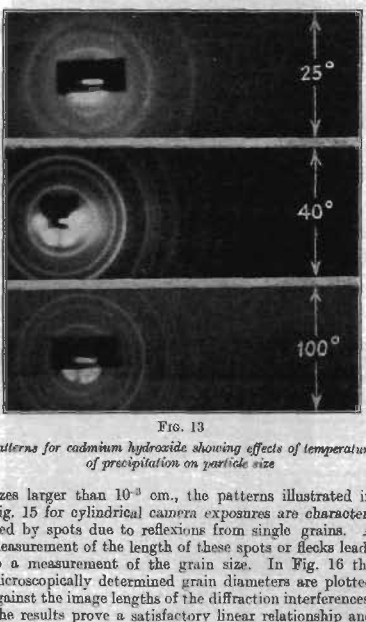


FIG. 13

Patterns for cadmium hydroxide showing effects of temperature of precipitation on particle size

sizes larger than 10^{-3} cm., the patterns illustrated in Fig. 15 for cylindrical camera exposures are characterized by spots due to reflexions from single grains. A measurement of the length of these spots or flecks leads to a measurement of the grain size. In Fig. 16 the microscopically determined grain diameters are plotted against the image lengths of the diffraction interferences. The results prove a satisfactory linear relationship and indicate the excellence of the standard microscopic values as well as the validity of the *X*-ray method. An entirely independent set of brass samples from another source and various steel specimens fully confirmed that this plot can be used in all cases where there is no residual fibre structure in the metal, and where due attention has been paid to divergence of the *X*-ray beam and to other variables. The new method should be of particular value in the determination of grain sizes of materials with which difficulty is experienced in resolving grain boundaries (which is essential for microscopic evaluation), and in the detection of grain growth

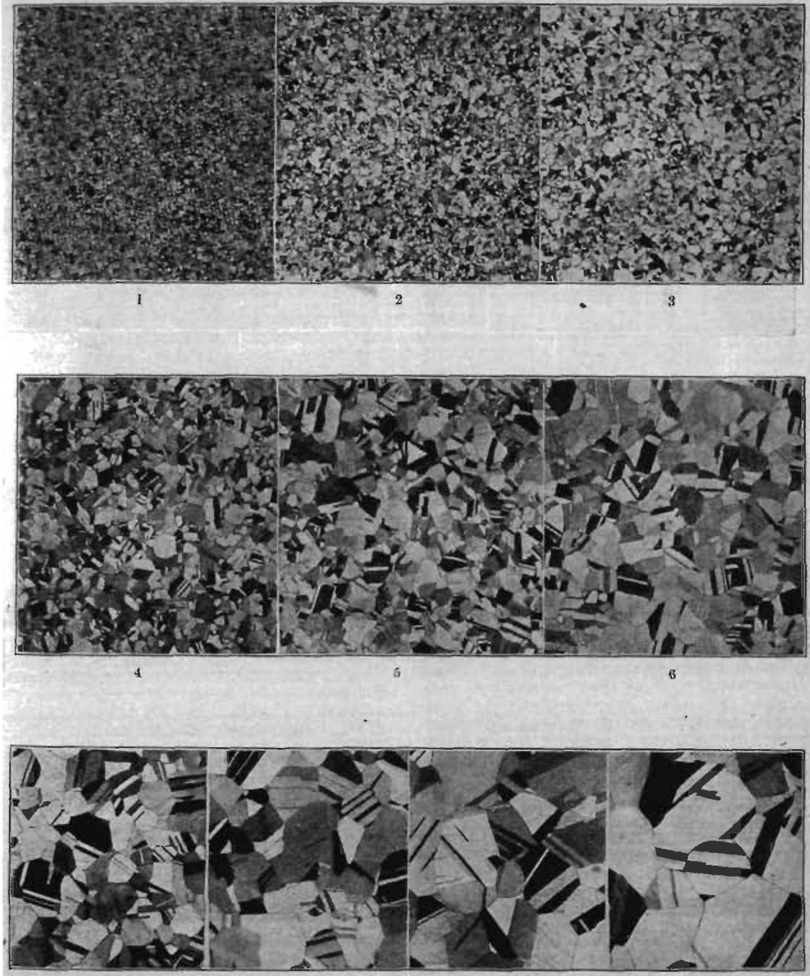


Fig. 14

A.S.T.M. standard grain size photomicrographs: 1. 0.010 *mm.* 2. 0.015 *mm.* 3. 0.025 *mm.* 4. 0.035 *mm.* 5. 0.045 *mm.* 6. 0.065 *mm.* 7. 0.090 *mm.* 8. 0.120 *mm.* 9. 0.150 *mm.* 10. 0.200 *mm.*

during the first stages when none of the grains have been completely absorbed and the grain count remains unchanged.

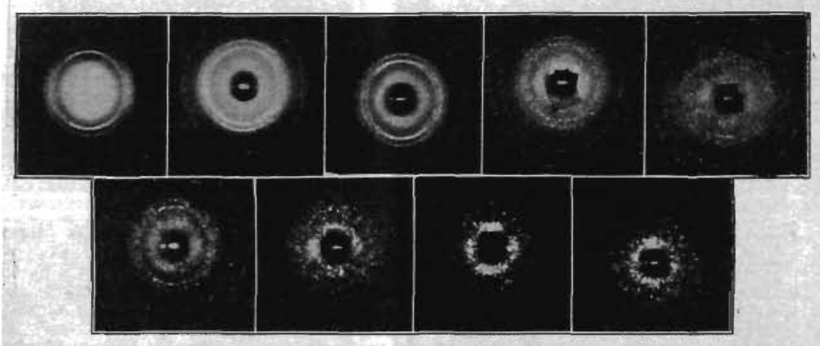
Paraffin waxes.—The first *X*-ray diffraction results on ordinary paraffin wax were obtained by the speaker in 1928 and results which are obtained even now are still of unusual interest. In spite of the fact that these waxes may contain as many as 18 or 20 different hydrocarbons, both normal and branched-chain isomers, a single diffraction spacing corresponding to molecular length is obtained, together with the usual side spacings. Clark first made *X*-ray measurements on a series of commercial waxes of varying melting points:

Wax melting point ° F.	d_1	Number of C atoms indicated
135	39·42	29·0
130	38·58	28·5
125	35·22	26·0
120	34·38	25·0

The spacing obtained varied, however, depending upon the method of preparing the specimen film (from 36·64 to 40·20 Å.U. for the 135° wax), and especially the time given for molecular orientation. Furthermore, the presence of addition agents in very small amounts served to change the long spacing. Obviously, possibilities of polymorphism, changing predominance of one molecular species over all others in the mixture, and changing tilts of molecules to the diffracting planes may explain the variations.

Clark and Smith next studied series of samples from carefully fractionated paraffin waxes derived from petroleum. Some conclusions are as follows: (*a*) No fraction is a single pure compound. (*b*) In fractions from the same wax the identity periods corresponding to the predominating molecular length follow no regular order with melting point; thus the largest spacing was obtained with the fraction with lowest melting point. (*c*) The number of orders of diffraction caused by the oriented molecules varies directly with the melting point of the fraction. This indicates that with the lower melting fractions the degree of perfection of orientation of the molecules becomes less, probably owing to the interference of an increasing number of molecules with lower orienting tendency. Excellent agreement between observed and calculated molecular refractions prove that these molecules must also belong to the paraffin series and are probably branched-chain molecules in view of the small variation in the observed molecular weight compared with large variation in melting point.

1 2 3 4 5



6 7 8 9

FIG. 15

Standard X-ray diffraction patterns for increasing grain size in the microscopic range. 1. 0·009 *mm.* 2. 0·012 *mm.* 3. 0·020 *mm.* 4. 0·033 *mm.* 5. 0·037 *mm.* 6. 0·045 *mm.* 7. 0·065 *mm.* 8. 0.085 *mm.* 9. 0.095 *mm.*

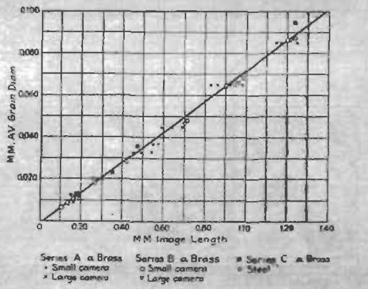


FIG. 16

Graphical correlation between image lengths of X-ray diffraction interferences and average grain diameters in microscopic range

This is further indicated by the fact that the side-spacing diffraction maxima corresponding to molecular cross sections become increasingly diffuse as the melting point becomes lower. (*d*) Molecular weights calculated from the *X*-ray data are about 25% higher than values by the ebullioscopic method. This indicates that besides containing the molecules indicated by the identity period every fraction is also made up of lower molecular weight paraffins, either shorter straight-chain or iso-paraffins, or both. (*e*) In 16 fractions only 5 spacings are observed corresponding to the values for pure hydrocarbons with 29, 31, 34, 38, and 42 carbon atoms by interpolation on the straight-line plot of d_1 against n. $C_{38}H_{78}$ and $C_{42}H_{86}$ were recognized as constituents of paraffin wax for the first time.

High-tension cables.—The phenomenon of the formation of waxy material within oil-impregnated high-voltage cables during stress has been one of the objects of this investigation. By the use of a beam of mono-chromatic *X*-rays and suitable control standards containing known percentages of wax, semi-quantitative determinations of the amount of wax in an oil may rapidly be made. The more important observations that were made during the course of the investigation were as follows: (*a*) The variation of the wax content of a stressed cable with the magnitude of the stress to which the cable has been subjected seems to be a direct relationship. (*b*) The wax content of a stressed cable, although nearly uniform for points further from the conductor than approximately 1 mm., increases sharply close to the conductor, being usually double or treble the value of the wax content near the centre of the insulation. (Fig. 17.) (*c*) Heating decreases the percentage of wax within the cable. (*d*) The wax content of the previously stressed cable slowly decreases with time as the cable remains unused.

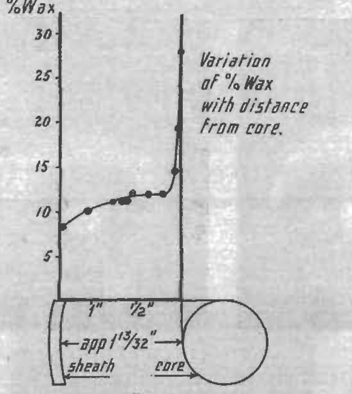


FIG. 17

Graph plotted from X-ray diffraction results for high-tension cable with broken-down insulation

Another phenomenon associated with stressed cables is the newly discovered presence of colloidal paper fibres within the paper tapes of the conductor. A large amount of research, both on the wax problem and upon the colloidal paper problem remains to be done.

Molecular orientation on the surfaces of drops.—The amazingly efficient method of orienting long-chain molecules in thin diffracting films on mercury drops was first published by Trillat in Paris, a notable advantage of the method being that the tangent *X*-ray beam impinges at just the right angle at some point in the spherical surface for diffraction to take place from the oriented molecules. It is a fascinating study to examine the surfaces of all kinds of drops for evidences of a preferred and regular orientation, as compared with the interior. The Langmuir-Harkins theories of molecular orientation and the orientation in thin lubricating films are thoroughly substantiated by this direct test. In Fig. 18 are compared the results for a liquid paraffin hydrocarbon drop, for a completely solidified drop, and for the invisible film formed by blowing a fine jet of air on the surface of a drop kept molten. The orientation in this thin film on the underlying liquid containing the same kind of molecules is quite astonishing. These few examples illustrate improvements in technique in this fascinating field of research, and at the same time the inevitable orienting tendencies on surfaces or interfaces. The oriented crystalline skin on cast glass and the skin effect of sulphides have been definitely discovered by these methods, even granting the imperfect crystallization in glass so well portrayed by Zachariasen.

Nile blue sulphate solutions.—When an *X*-ray beam passes through a liquid or solution, a pattern is produced characterized by diffuse haloes. Stewart's explanation of cybotaxis or transient regular grouping of molecules in liquids is now generally accepted. In colloidal solutions there is observed a halo or scattering at very small angles, and Krishnamurti has made use of this phenomenon to estimate the state of aggregation of various colloidal solutions. Experiments in our laboratory have been under way for some time to test the validity of interpretations of these diffuse patterns. Solutions of Nile blue sulphate, an oxazine dye, are particularly advantageous since Dr. Barnett Cohen of the United States Public Health Service has discovered from spectrophotometric and electrometric observations that there is clear evidence of the existence of at least two molecular phases or species, the proportions of which are determined by the amount of dye in solution. According to these results Nile blue in concentrations of the order of one-millionth molar in water approaches obedience to the laws of dilute solutions, while in the range of moderate concentrations the dye acts as if associated to form micellar structures. In order to test these conclusions diffraction photographs were made and then analysed very carefully with the microphotometer, and it was found that the position of the inner

Concentration	Angle inner edge	*d* in Å.U.
0·00884	1°49′	11·19
0·000884	1°59′	10·26
0·0000884	2°30′	8·14
0·00000884	2°52′	7·10

This is further indicated by the fact that the side-spacing diffraction maxima corresponding to molecular cross sections become increasingly diffuse as the melting point becomes lower. (*d*) Molecular weights calculated from the *X*-ray data are about 25% higher than values by the ebullioscopic method. This indicates that besides containing the molecules indicated by the identity period every fraction is also made up of lower molecular weight paraffins, either shorter straight-chain or iso-paraffins, or both. (*e*) In 16 fractions only 5 spacings are observed corresponding to the values for pure hydrocarbons with 29, 31, 34, 38, and 42 carbon atoms by interpolation on the straight-line plot of d_1 against n. $C_{38}H_{78}$ and $C_{42}H_{86}$ were recognized as constituents of paraffin wax for the first time.

High-tension cables.—The phenomenon of the formation of waxy material within oil-impregnated high-

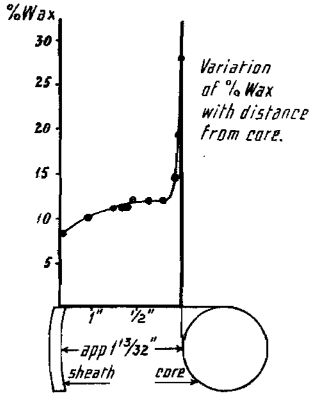


Fig. 17

Graph plotted from X-ray diffraction results for high-tension cable with broken-down insulation

voltage cables during stress has been one of the objects of this investigation. By the use of a beam of monochromatic *X*-rays and suitable control standards containing known percentages of wax, semi-quantitative determinations of the amount of wax in an oil may rapidly be made. The more important observations that were made during the course of the investigation were as follows: (*a*) The variation of the wax content of a stressed cable with the magnitude of the stress to which the cable has been subjected seems to be a direct relationship. (*b*) The wax content of a stressed cable, although nearly uniform for points further from the conductor than approximately 1 mm., increases sharply close to the conductor, being usually double or treble the value of the wax content near the centre of the insulation. (Fig. 17.) (*c*) Heating decreases the percentage of wax within the cable. (*d*) The wax content of the previously stressed cable slowly decreases with time as the cable remains unused.

Another phenomenon associated with stressed cables is the newly discovered presence of colloidal paper fibres within the paper tapes of the conductor. A large amount of research, both on the wax problem and upon the colloidal paper problem remains to be done.

Molecular orientation on the surfaces of drops.—The amazingly efficient method of orienting long-chain molecules in thin diffracting films on mercury drops was first published by Trillat in Paris, a notable advantage of the method being that the tangent *X*-ray beam impinges at just the right angle at some point in the spherical surface for diffraction to take place from the oriented molecules. It is a fascinating study to examine the surfaces of all kinds of drops for evidences of a preferred and regular orientation, as compared with the interior. The Langmuir-Harkins theories of molecular orientation and the orientation in thin lubricating films are thoroughly substantiated by this direct test. In Fig. 18 are compared the results for a liquid paraffin hydrocarbon drop, for a completely solidified drop, and for the invisible film formed by blowing a fine jet of air on the surface of a drop kept molten. The orientation in this thin film on the underlying liquid containing the same kind of molecules is quite astonishing. These few examples illustrate improvements in technique in this fascinating field of research, and at the same time the inevitable orienting tendencies on surfaces or interfaces. The oriented crystalline skin on cast glass and the skin effect of sulphides have been definitely discovered by these methods, even granting the imperfect crystallization in glass so well portrayed by Zachariasen.

Nile blue sulphate solutions.—When an *X*-ray beam passes through a liquid or solution, a pattern is produced characterized by diffuse haloes. Stewart's explanation of cybotaxis or transient regular grouping of molecules in liquids is now generally accepted. In colloidal solutions there is observed a halo or scattering at very small angles, and Krishnamurti has made use of this phenomenon to estimate the state of aggregation of various colloidal solutions. Experiments in our laboratory have been under way for some time to test the validity of interpretations of these diffuse patterns. Solutions of Nile blue sulphate, an oxazine dye, are particularly advantageous since Dr. Barnett Cohen of the United States Public Health Service has discovered from spectrophotometric and electrometric observations that there is clear evidence of the existence of at least two molecular phases or species, the proportions of which are determined by the amount of dye in solution. According to these results Nile blue in concentrations of the order of one-millionth molar in water approaches obedience to the laws of dilute solutions, while in the range of moderate concentrations the dye acts as if

Concentration	Angle inner edge	*d* in Å.U.
0·00884	1°49′	11·19
0·000884	1°59′	10·26
0·0000884	2°30′	8·14
0·00000884	2°52′	7·10

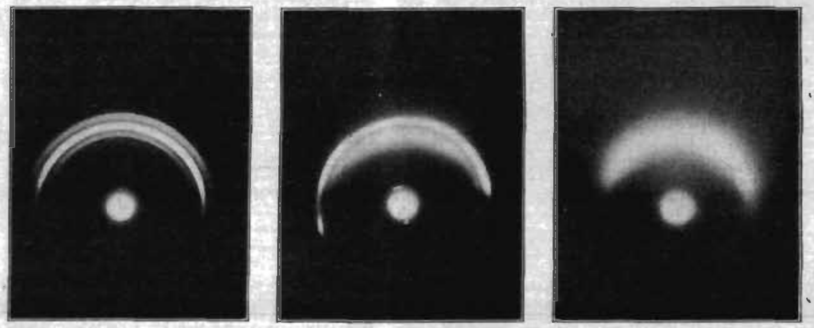
associated to form micellar structures. In order to test these conclusions diffraction photographs were made and then analysed very carefully with the microphotometer, and it was found that the position of the inner

edge of the principal halo depended markedly on the concentration.

It was clearly evident that the state of aggregation changes with concentration, especially between 0·0009 and 0·00009 molar. With still greater concentrations, the pattern of precipitated Nile blue began to appear and at lower concentrations the pattern was practically indistinguishable from that of pure water. The scattering of *X*-rays by dissolved molecules and molecular aggregates appears to be a real phenomenon which can be interpreted to very practical advantage, especially in the study of colloidal solutions.

Balata, gutta-percha, chicle, rubber, and duprene. In 1926 in the laboratory at the Massachusetts Institute of Technology were made the first diffraction studies of balata and gutta-percha. It was indicated then that the two gave diffraction patterns different from each other and from those of rubber. Last year the work was taken up again and it was discovered independently in this laboratory and by Hauser and von Susich in Germany that there are α and β modifications of the gutta-percha hydrocarbon, and that this hydrocarbon is the essential constituent of balata and chicle. It is also likely that crystals isolated from rubber are this same hydrocarbon. Many curious facts concerning these natural substances are thus explained upon the basis of *X*-ray studies alone. The structure of stretched rubber is now so familiar to everyone that little further comment seems necessary. Increasing micellar size as indicated by diffraction patterns for vulcanized rubber seems to prove more and more definitely that smaller aggregates are bound into larger ones by sulphur bridges. Great interest has been aroused by the recent production of chloroprene or duprene, the first synthetic rubber to give a rubber-like diffraction pattern on stretching.

Cellulose.—This natural highly polymerized substance has been subjected to a very large amount of *X*-ray investigation, and yet it remains a difficult and fascinating subject. The structure of the crystalline part of natural cellulose including the linkage of dehydrated glucose residues through oxygen bridges into long primary valence chains, the bundling of these into micelles, and the varying types of orientations of the micelles in the fibre, have all been repeatedly substantiated, although it is safe to say that the structure is still tentative. Continued research on cellulose in this laboratory has been along the following lines: (1) Efforts to register more and more interferences on diffraction patterns, particularly at large angles. Fig. 19 reproduces quite imperfectly a recently obtained pattern of ramie cellulose which has more detail and a larger number of interferences than any observed in our experience. Complete measurement and interpretation are under way. (2) A comparison of ancient cottons, jungle cotton, and other types with modern varieties. Some of the ancient specimens represent a highly preferred parallel orientation of micelles superior to modern cotton. (3) Increasing control over the properties of both cotton and rayon by swelling and tension methods which pull micelles into parallel alignment. Changes for the better in commercial rayons as a result of application of *X*-ray method are generally familiar. (4) Proof of cellulose synthesized from sugars by Hibbert and associates. (5) An expanding study of growth and development of cellulose, particularly cotton. The results on daily growth of cotton from the root hair to the mature fibre have been reported already. *X*-ray examination shows when wall thickening begins and the first evidences of preferred orientation of cellulose laid down from the cytoplasm. Experiments on the structural factors in growth under different humidity,



A B C

Fig. 18

Diffraction patterns, showing molecular orientation in surfaces. A. Surface of solidified drop; B. Surface of molten drop cooled by jet of air; C. liquid drop

spectral conditions are under way. It is possible to classify cotton upon the basis of diffraction patterns. (6) An improvement in technique making it possible to study single fibres. The enormous variation in structure

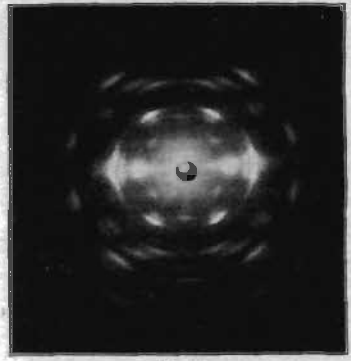
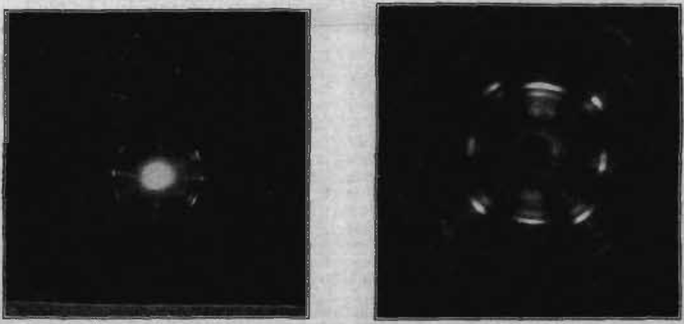


Fig. 19

Pattern for cellulose (ramie) showing great detail

in different parts of the *same* fibre has become clearly *evident from microscopic studies. This being the case,* the diffraction pattern of the bundle of fibres previously used for specimens is an integration from which distinctions would be difficult or impossible. A suitable small patterns. Experiments are now in progress to prepare patterns for a single fibre from root to tip. There is a microbiological variable in the growth of these natural fibres which must now be *recognized* and the control of which must be attempted. (7) Further studies of the mechanism of dyeing and absorption: these have great theoretical and practical importance in textiles and in the production of absorbent cotton. A pattern was made recently for a cotton sample which had been treated with soap solution in order to ascertain something more about inner micellar surfaces. In spite of the minute amount of absorbed soap, the *X*-ray pattern showed clearly rings indicating an oriented interior film of soap molecules which extended longitudinally and radially from the vertical axis of the fibre, and evidently attached to the inner micellar surfaces. The possibilities of *X*-ray research on textile materials are clearly far from exhausted.

Protein fibres.—The results of more than three years' research on wool, hair, silk, collagen, catgut, surgical sutures, and human tissues would require a volume. In the meanwhile the magnificent work by Astbury on wool and hair has appeared. His observation of a molecular α to β transformation in hair or wool upon stretching has been completely substantiated in the study of the loss of resiliency in wool felts. The effects of reagents of all kinds on wool structure and especially the effects of p_H on either side of the isoelectric point are directly indicated from the diffraction patterns. It is undoubtedly at the isoelectric point that the protein *molecule is most resilient, since* COO^- *and* NH_3^+ *groups* along the chain exercise attractive forces. The selection of natural catgut, the improvement in strength upon swelling and tension, the relationship between absorption



Al-Cold Rolled

Fig. 20

Patterns for cold-drawn aluminium wire made in single-fibre camera as compared with usual type

camera has finally been developed in the course of many months' work, in which the minute amount of diffracting material represented by a single fibre is sufficient to produce a pattern. Fig. 20 shows the pattern for a single very fine metal wire and Fig. 21 that for a single cotton fibre. Bundles of four fibres produce beautiful time in the tissues and structure have all been studied by diffraction. The diffraction study of normal and pathological tissues begun three years ago has led to the installation of diffraction equipment in clinics and hospitals—and a third great medical application of *X*-rays is added to radiographic diagnosis and therapy.

Long-wave diffraction analysis and the structure of insulin.—The diffraction of *X*-rays by materials is governed by the Bragg law $n\lambda = 2d \sin \theta$, where λ is the wave length, n is an integer, d is the distance between diffracting planes, and θ is the angle of incidence. Examination shows that with constant λ for increasing values of d, a fundamental spacing characteristic of a given substance, the angles at which diffraction maxima occur become smaller, until they may not be resolved from the undeflected portion of the primary *X*-ray beam. The only recourse is to make use of a larger value of λ. A beam of rays generated at a magnesium target will have the principal wave length 9·86 Å.U. as contrasted with 1·54 and 0·71 Å.U. respectively for the almost universally employed copper and molybdenum targets. A combined *X*-ray tube and diffraction apparatus was constructed three years ago and the first successful measurement of micellar size by direct diffraction was made for cellulose and rubber. One of the values for

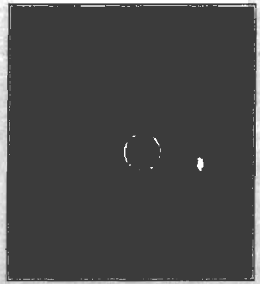


Fig. 21

Pattern of single cellulose fibre

cellulose so observed corresponds exactly with the cross-section dimensions of cellulose micelles recently made by Thiessen with the Spierer lens. This would seem to be one of the most convincing proofs of the micellar construction of these natural polymerized materials. Efforts have now been made for two years in this laboratory by Freudenberg and others to obtain crystal diffraction patterns for crystalline insulin. These patterns showed nothing but a periodicity of about 3·8 Å.U. common to proteins. The writer had the feeling that this substance might be so complex, and its unit crystal cell so large that interferences could not be observed by ordinary technique. Accordingly a crystal was mounted in the long-wave apparatus with magnesium apparatus. An unmistakable diffraction pattern was photographed corresponding to unit monoclinic cell dimensions of 80 × 100 × 130 Å.U., each cell containing 24 molecules with a molecular weight of 35,000—the largest ever observed. Thus an entirely new field for the study of very complex substances is opened.

It is hoped that these examples from the last year of a decade of research may speak for the promise of a youthful industrial science.

SEWAGE TREATMENT AND DISPOSAL

A NEW AMERICAN PROCESS

The persistence of the problem of sewage-sludge disposal is a good example of the truism that the advantages of civilization are frequently accompanied by corresponding disadvantages. There is no doubt that the modern water-carriage system of sewage disposal, or rather conveyance, is a great advance on its predecessor; but it is very costly in land, in materials, and in human labour, involving not only the laying of untold miles of drain-pipes, but also costly equipment for purification. Moreover, the high manurial value of the sludge is largely lost, and only one modern process, the activated-sludge process, provides a fertilizer of outstanding value; but this, however, cannot be marketed because it cannot be economically dried.

A new process emanating from the U.S.A., developed by G. H. Gleason and A. C. Loonam, working on behalf of Guggenheim Brothers, combines a modification of the well-known method of chemical precipitation with a novel use of the base-exchange material zeolite for purifying the effluent. Preliminary experiments showed that ferric iron was the best tervalent kation for coagulating raw sewage, and that lime was the best alkali, being the least expensive and producing the densest precipitate.

The sewage is passed through coarse and fine screens, to remove the coarser suspended solids, into a tank where ferric sulphate is added, and air is passed continually through the liquid to keep the iron oxidized. Lime is added in a second tank, equipped with a flocculating mechanism, and the time of flocculation, as well as the hydrogen-ion concentration, is rigorously controlled.

The liquid is then passed into a "clarifier," where the sludge settles and the supernatant liquor overflows on to the zeolite beds. The sludge is pumped to a suction filter, where its moisture-content is reduced by about 80%, and is then completely destroyed in a rotary-kiln incinerator consisting of two sections: one in which the sludge is dried (at 110—150° C.) and one where it is burnt (at 650—700° C.). The calorific value of the sludge is, when the scale of operation is sufficiently large, adequate to ensure complete combustion. From the ash, containing about 41% of ferric oxide, ferric sulphate is regenerated by treatment with sulphuric acid at 150° C.; and the regenerated material is found to be a better precipitant than the original, or any other purchasable salt.

In the zeolite bed, the supernatant liquor from the clarifier is deprived not only of remaining suspended matter, but also of the putrescible organic compounds that have escaped precipitation. The basic nitrogen of these compounds is exchanged for the sodium in the zeolite. About 16,000 lb. of zeolite is required per million gals. of sewage treated, and the rate of loss is very small. After remaining from 10 to 12 hours in contact with the zeolite, the liquid is passed to a second bed of the same material, and the original bed is regenerated by washing with a concentrated (20%) solution of common salt. The basic nitrogen is transferred to the salt solution, and this is treated with lime and distilled. The salt solution becomes available for further use, and the ammonia liberated is also recovered.

The degree of purification attained on a small plant with a daily capacity of 2,500 gals. of sewage, which was operated continuously for eight months at New York, is shown by the following data :

	Crude sewage	Purified effluent
Suspended solids (aver.)....	200 parts per million	1 part per million
B.O.D. (aver.)	150 do.	5 do.
Total nitrogen (aver.)	24—28 do.	2—3 do.
Ammonia nitrogen (aver.)	12—14 do.	0·5—1·0 do.
Bacteria per c.c.	3—6 million colonies	—
Total bacteria removed	—	99·1%
B. coli removed	—	99·6%

These results are considered so satisfactory that a plant to treat 25,000 gals. per day has been ordered for Chicago.

Little that is definite can be said at present regarding the cost of plant and treatment. It is thought that the plant will not occupy more than about one-half of the area demanded by other types of plant giving equal purification ; and that a plant of 50 million gals. capacity, or more, will cost, in the Eastern States or in the Lake cities, about two-thirds that of an activated-sludge plant of similar capacity. Operating and maintenance costs are estimated at 22 dollars per million gals. of sewage treated in a plant of the above-mentioned capacity ; but this figure does not include interest or amortization charges, nor any credit for the value of the ammonia recovered.

ASSOCIATION OF TAR DISTILLERS

The annual dinner of the Association of Tar Distillers was held at the Café Royal on April 11 and was well attended, about a hundred and thirty members and guests being present. *There were facilities before the* dinner for conversation with those aids to it that now characterize our solemn feasts. Mr. R. Alsop, the president, took the chair and was duly encouraged by the presence of the new president, Capt. C. F. Ward Jones, and the new vice-president, Mr. J. R. Lane. The speeches were eminently suitable for such a gathering and neither their length nor their gravity proved to be in any way excessive. Among those present, in addition to those already mentioned, were Dr. E. F. Armstrong, Mr. Percy Ashley, Sir Charles H. Bird, Mr. F. Bird, Mr. R. R. Bird, Col. C. H. Bressey, Dr. J. C. Bridge, Dr. T. H. Butler, Sir James Calder, Mr. C. E. Carey, Mr. R. G. Clarry, M.P., Mr. W. E. Cone, Mr. W. A. Damon, Capt. C. Frobisher, Mr. R. C. B. Gardner, Mr. A. Hittinger, Mr. J. H. Hughes, Mr. H. W. James, Mr. J. M. Johnston, Major C. G. Lyon, Mr. C. le Maistre, Sir John Stirling Maxwell, Bart., K.T., Prof. G. T. Morgan, Mr. J. H. Olliver, Dr. D. D. Pratt, Mr. J. Davidson Pratt, Sir Robert Robertson, Dr. J. A. Roelofsen, Major A. G. Saunders, Mr. J. Shearman, Dr. F. S. Sinnatt, Mr. W. J. Smith, Mr. W. M. Valon, Mr. W. A. Walmsley, Mr. H. E. G. West, and Mr. W. J. U. Woolcock. This brief account of the dinner very inadequately expresses the care taken by those who organized it to anticipate the wishes of busy men who towards the end of the day naturally require a little refreshment of body and mind.

SOCIETY OF CHEMICAL INDUSTRY

OFFICIAL NOTICES

Annual Meeting. The annual meeting of the Society will be held in Newcastle from July 10–14 inclusive. The annual general meeting will form part of the proceedings and will begin at 11 a.m. on Tuesday, July 11. A full preliminary programme of the week was published in the issue of March 31. A detailed programme will be issued by post to every member in due course. It will assist the organizers in the meantime if notice of intention to take part be given now or in the near future.

John Gray Jubilee Scholarship. The scholarship is of the approximate value of £72 and is tenable for one year by a post-graduate worker at an approved seat of learning or research. Candidates at the time of application must have the intention of entering industry : preference will be given to sons of members of 10 years' standing. Undergraduates preparing to sit for their final degree examinations are eligible.

Applications should be addressed to the General Secretary, Society of Chemical Industry, 46, Finsbury Square, London, E.C.2, before June 30 and should furnish particulars of school and university careers and give references to persons who will testify to candidate's character.

BIRMINGHAM SECTION

The subject of "Refractories" was dealt with in a paper by Mr. C. R. F. Threlfall (director of Messrs. Timmis & Co., Ltd.) and Mr. A. T. Green (assistant director of research of the British Refractories Research Association) at a meeting of the Birmingham and Midland Section held at the University of Birmingham on *Thursday, April 6. Mr. H. W. Rowell presided.*

The authors pointed out that chemistry and ceramics sometimes appear to be far apart and that probabilities often take the place of exact knowledge. In ceramics widely variable raw materials provide finally, as the result of an "arrested reaction," a partially fused mass. Chemical analysis of a raw clay is quite inadequate in itself to indicate whether bricks made from that clay will be satisfactory. The real tests are purely physical, helped out by petrographic and microscopic or *X*-ray examination. The life of the brick depends mainly on its physical properties and these to a considerable extent can be controlled during the course of manufacture. It is the duty of investigators in the field of refractories to search out and indicate the physical properties desired, and to assist the manufacturer to incorporate them in his products. The future of the ceramic industry would appear to lie with the engineer of originality and of scientific education who has superimposed on a sound fundamental basis of chemistry and physics sufficient elasticity of mind to jettison all his previous learning if the occasion appears to demand it. The industry has always been self-contained and its technique has suffered thereby. The authors then indicated briefly the occurrence of refractory materials in Great Britain.

In discussing brickmaking they pointed out that the production of a brick of some kind is a very simple

matter, but that the manufacture of really good bricks can only be obtained by clever engineering and by a difficult technique. An analogy is drawn between making a brick and making an omelette. The chief difficulty of brickmaking is the preparation of the body and this is mainly a matter of mixing. The ingredients of a clay body are green clay, grog, and water, and the object is to obtain an absolutely uniform dispersal of water throughout the mass so that every grain of grog is coated with green clay and will adhere to each of its neighbouring grains on burning. If too much water is used the grading of the green clay grains will be broken down, and if too little is used the mass will be starved and only partly plasticized. The viscous and heavy mass obviously demands a type of mixing which is ingenious, efficient, and of long duration, and this is very often precluded by the price at which the article can be sold. Ageing a body does little more than carry on the mixing by the gradual dissemination of the water throughout the mass. Various chemical clay "improvers" are now being largely used, such as hydrochloric acid or cellulose sulphite lye, and a comparison is made with the difficulty which Moses had in making bricks without the addition of (chopped and decomposed) straw. Reference was made to the effect of pressure during mixing, particularly where only slightly plastic materials were being used, some types of which it was absolutely necessary to put under an edge runner mill to obtain a workable body. The briquetting of coal dust and tar was instanced. As regards grain size of the particles the authors pointed out the very striking effects which are obtained when the materials to be mixed are first of all graded and the various grades added one by one, and also the effect of an alteration in the order in which the different grades are added. The different types of the common refractory materials were then discussed together with their characteristics, with peculiar reference to their physical properties of which the most important were their resistance under load and their porosity. The whole tendency of modern "super" brick manufacture is towards the obtaining of the lowest possible porosity and permeability (which are quite different characteristics) without abnormal vitrification. In the past nearly all work on porosity and its effects was carried out within very narrow limits from about 22% to 30%, and a great many of the preconceived ideas (particularly about spalling) are likely to be upset by a complete investigation of porosities from 0% up to 20%. High porosity is generally an indication of structural weakness and of bad brickmaking. The authors discussed the testing of and the specifications for refractory materials and suggested that in future a great deal of attention is likely to be directed by the purchaser to tests on the green body rather than on the finished brick, but issued a warning against an inadequate understanding of the exact conditions under which the bricks will have to work. Shape was discussed with a plea for the general simplification and lessening of furnace shapes in order that more attention might be paid to proper body preparation, and they pointed out that for a given construction less cement can actually be used with small bricks than with large and complicated pieces owing to the greater ease of handling and laying. Spalling was discussed at some length and the opinion expressed that low porosity, apart altogether from its help in excluding from the body of brick foreign matter which will act as a spalling agent, is probably a desirable characteristic.

As regards permeability, which is the property of the penetration of gases or slags through the body, it was pointed out that the permeability varies very greatly indeed in the various planes of the brick and that a brick which is unsatisfactory when working on the 4½-in. way may be very good indeed if set to work on the 3-in. way.

In an explanatory lecture Mr. Green illustrated the points raised by a critical survey of the factors influencing the life of the bricks in a blast furnace lining and a vertical retort setting. As far as blast furnaces were concerned, the daily rate of charge and the total throughput required (now 1½ million tons) laid a heavy burden on the refractories which was not always lessened by the design or method of operating the furnace. He mentioned the disintegrating effect of the attack by the alkali (potassium carbonate and potassium cyanide) formed in the bosh, mentioning how it penetrated right into the brick. There was also the question of carbon monoxide, which penetrated the brick, breaking it down at 500° C., deposited carbon in the pores, and disrupted the brick, this disrupted mushy layer following an isothermal line right down the wall. There was also the severe action of high velocity gases containing incandescent dust which was particularly severe in the zone just above the bosh at the base of the stack. The action of zinc vapour also had to be considered, whilst there was also the problem of direct slag attack in the hearth, bosh, and lower part of the stack. The old size of block which took two men to lift and lay was very properly going out of fashion, the smaller size of to-day rendering possible better bricklaying with less jointing cement, and a very much less permeable body, better able for this reason to resist all the types of attack above instanced.

In a vertical retort setting the trouble of flaking was mentioned. This was due to a surface weakening of the face of the brick at the zone of greatest temperature of scurfing (periodic removal of deposited carbon). The carbon actually penetrated the brick and caused strains both when being deposited and when being burnt off, though the nature of the scurf itself varied greatly with the coals carbonized. A gas retort differed from a blast furnace in that in the retort the hot face was outside, whereas with the blast furnace it was the interior face. Having the hot face outside tended to make the slag penetration worse as a sucking action was set up which tended to replace with slag the original matrix of the brick. For a vertical retort bricks of a low porosity and of a low permeability were advised as was the zoning of the retort, *i.e.*, the construction of the different zones of the retort out of different and suitable refractory materials.

The chairman and Mr. T. F. E. Rhead (chief chemist, Birmingham Gas Department) took part in the discussion.

LIVERPOOL SECTION

A joint meeting of the Liverpool Section with the Institution of Chemical Engineers and the Chemical Engineering Group was held on Friday, April 7, in the University of Liverpool, at 6 p.m. The president of the Institution of Chemical Engineers, Viscount Leverhulme, was in the chair.

The president, in his introductory remarks, made reference to the fact that this was the first occasion on which the Institution of Chemical Engineers had held a meeting in Liverpool, and expressed his pleasure that it had fallen to his lot, as one closely identified with the industry, with Merseyside, and also as the Pro-Chancellor of the Liverpool University, to preside over the deliberations.

A paper entitled "The Corner Metals of Electrical Distribution—Copper, Aluminium, and Lead" was delivered by Dr. F. J. Brislee (British Insulated Cables, Ltd.). The properties of copper, aluminium, and lead were dealt with from the standpoint of their uses in electrical distribution. Recent work on copper and lead was reviewed, and the failures of these metals under specific conditions was discussed.

Other points dealt with were the corrosion of these metals and their behaviour when exposed to conditions which cause corrosion, the intercrystalline failure of lead under stress and vibration, and the means available for combating the trouble. The association of three dissimilar metals together for the distribution of electrical energy gives rise to problems which were outlined.

A discussion followed in which Mr. C. S. Imison, Mr. J. A. Todd, Mr. W. E. Ford, Prof. C. O. Bannister, Dr. A. Parker, and Mr. W. A. S. Calder took part.

A vote of thanks was proposed by Mr. J. Arthur Reavell and seconded by Mr. E. Gabriel Jones, chairman of the Liverpool Section.

After the meeting an informal dinner was held at the University Club, at which there was a large attendance.

In the afternoon, by kind invitation of the City Electrical Engineer, Mr. P. J. Robinson, M.I.E.E., a party of between 60 and 70 was shown over the Liverpool Corporation Central Electrical Power Generating Station, Clarence Dock.

MONTREAL SECTION

A meeting of the Montreal Section was held on February 22 at the McGill University Chemistry Building when Dr. D. L. Thomson, of the Biochemical Department, McGill University, read a paper on the subject of "The Chemistry of Foods" which, he said, could be summed up in two aphorisms: "Food is a fuel," and "Food is more than a fuel."

The discovery by Lavoisier that the animal body may be likened to a combustion engine, in which the organic substances of the food are oxidized to provide energy, is the starting-point of modern biochemistry. The three chief classes of oxidizable materials, the proximate principles, are the carbohydrates, the fats, and the proteins. The last differ from the others in containing nitrogen. The animal body cannot oxidize this nitrogen to nitrates or even set it free as elemental nitrogen, but must split it off from the products of protein digestion in the form of ammonia. Since ammonia is highly toxic, it must be rapidly converted into a harmless substance, such as urea. This process is carried out in the liver by a complex chain of reactions involving the synthesis of arginine from ornithine by addition of ammonia and carbon dioxide. It is highly efficient, so that although some 15 g. of ammonia are produced daily in the body, the amount present in the blood does not exceed 0·01 mg. per hundred c.c. The urea formed is not volatile and hence cannot be got rid of by the same channels as carbon dioxide and water; a special excretory system—the kidney—has been evolved for the disposal of such nitrogenous waste products, but has also acquired other functions such as the regulation of the hydrogen ion concentration and osmotic pressure of the body fluids. Because of the special problems involved, protein does not yield as much heat in the body as when burned in the calorimeter; in this it differs from fat and carbohydrate.

It is interesting to inquire what are the actual energy needs of the body. At the lowest possible level, under resting conditions, the "basal metabolic rate" varies with height, weight, sex, and age. A specimen figure, for a young man weighing 165 lb., is 1800 large calories per day. This is an energy output equivalent to 90 watts, or one-eighth of a horse-power, or more than enough to raise the man's body weight to the top of the Empire State Building (1250 ft.) every hour. The heat production of the body can be measured in various ways. With the use of complex and very expensive apparatus, it is possible to measure the amount of heat evolved directly, in an insulated chamber. Since fats and carbohydrates yield carbon dioxide and water in different proportions, when completely oxidized, and hence give different ratios of carbon dioxide produced to oxygen consumed, it is possible to determine the proportions of fat and carbohydrate oxidized in the body and eventually the absolute amounts by analysis of the inspired and expired air; the protein consumption can be calculated from the nitrogen excretion. Since the amount of heat yielded by unit weight of each of these foodstuffs is known, the total heat production of the body may be calculated with considerable accuracy. Thirdly, since the oxygen consumed by the body is rapidly liberated again as carbon dioxide and water, the loss of weight of the body is a measure of the rate of oxidation and of heat production, under suitable conditions.

Although the body may evolve energy for short periods at rates very much above the resting rate, temporarily increasing its heat production even fifty-fold, there is really surprisingly little difference in energy output between a day of absolute rest and a day including an eight-hour period of moderately strenuous muscular work; if the basal metabolic rate is 1800 calories, the heat production in a working day is not likely to be above 3200 calories except in the case of persons leading exceptionally strenuous lives. Two pounds of bread would yield one pound of carbohydrate, and a quarter of a pound of protein; if a quarter of a pound of butter were added, the total value of such a diet would be about 3450 calories, an entirely adequate

igure. A gallon of gasoline (petrol) would yield about en times this quantity of heat.

Such a diet, though adequate from the point of view f energy content, might be deficient in other respects, ince food is more than a fuel. Unlike the machine, he body can repair itself and make good wear and ear, provided the materials are available. Fortunately t is not necessary that every chemical substance in the ody should be represented in the diet, since many f them can be synthesized, but their components must e present. Thus since haemoglobin, the red pigment f the blood, contains iron, and since red blood corpuscles ave a short life and soon break down and their iron is xcreted, it is obviously essential that the diet should ontain iron. Recent work has emphasized the import-nce of traces of other elements, such as copper, magne-ium, and manganese. There are, however, certain rganic compounds which play an essential part in the conomy of the body and which the body cannot ynthesize from other materials ordinarily present in the ood. These include certain amino-acids (from which roteins are built up), certain fatty acids, and the hemically heterogeneous group of the vitamins.

Extraordinary progress has been made in the last wo years in deciphering the chemistry of the vitamins. Vitamin-*A* has been obtained from fish-liver oils in a tate approaching purity, and is recognized as a derivative f carotene, the orange pigment of carrots. Vitamin-*B* s a complex of several water-soluble substances, and it s not known how many of these are important for uman welfare; the best known, that which prevents eri-beri, has been obtained in a practically pure state nd is a base containing nitrogen and probably sulphur; ne of the other members of the series (B_4) has also been solated. Vitamin-*C*, which prevents scurvy, has recently een recognized as an acid related to the carbohydrates; ts constitution has been established by Micheel and Kraft. Vitamin-*D* prevents rickets by improving absorption of phosphorus and calcium from the intestine; a substance which has this property has been isolated n pure state from the complex mixture of isomers produced when the solid alcohol ergosterol is irradiated with ultra-violet light. Whether this extremely potent pure substance (calciferol) is identical with the naturally-occurring vitamin-*D* of cod-liver oil is not yet certain, and doubt has been cast on the assumption of identity by recent experiments on chickens. It is not unlikely hat other vitamins still await discovery and demonstra-ion.

CHEMICAL SOCIETY

The meeting held on April 6 was devoted to a com-nemoration of Joseph Priestley (1733–1804). Addresses vere delivered by Sir Philip Hartog, Prof. A. N. Meldrum, nd Sir Harold Hartley, and exhibits of manuscripts, pparatus, medallions, and other memorials of Priestley vere lent by the Royal Society, Dr. Alexander Scott, Mr. George H. Gabb, Mrs. Arundell Esdaile, Mr. W. C. Priestley, Dr. C. H. Spiers, and Dr. J. A. Newton Friend.

Before the proceedings commenced, the president, Prof. G. T. Morgan, O.B.E., F.R.S., referred with deep egret to the death of Prof. John Millar Thomson, who vas elected a Fellow in 1872 and had served as a member of the Council, as secretary, and as vice-president over periods amounting to 31 years; he was also chair-man of the Library Committee for 19 years. A resolution of the Council, recalling with gratitude the eminent services which his wide knowledge enabled him to render to the Society, and mourning the loss of one who by his great personal qualities endeared himself to all with whom he came into contact, was read by the president. Fellows meanwhile standing.

Sir Philip Hartog said that the lightning sketches to be drawn by the three speakers would all be different. He wished to throw some light on Priestley's own peculiar personality and history as a scientific man and theorist, for in some ways Priestley had been singularly misjudged. He had an amazing facility for mastering different subjects; he published some fifty works on theology, thirteen on education and history, about eighteen on political, social, and metaphyisical subjects, and twelve books and some fifty papers dealing with physics, chemistry, and physiology (animal and vege-table). He also knew Latin, Greek, French, German, Italian, Hebrew, Chaldee, and Syrian, and began Arabic. Priestley had definite purposes before him, and was a man of extraordinary method. The main purpose of his life was one of religion and piety; his love of science, which he regarded as a relaxation, became obvious at a very early stage. While a minister at Nantwich, at the age of 25, he made his first experiments in science to please himself and the thirty or forty pupils at his school. His first scientific work was a History of Electricity; from his first preface onwards, Priestley contrasts the use of speculation with the discovery of facts, and he has a clear vision of the value of hypothesis in scientific investigation. Sir Philip Hartog dispnted the state-ment that Priestley in theory had no instinct for guessing right, and gave instances of his power of generalisation. From 1770 onwards his scientific work was almost eutirely related to chemistry. Slipping into chemistry, as it were by a side door, and finding only one theory of any generality, the phlogiston theory, he adopted it without question. Although at one time he became a convert to Lavoisier's new ideas, he later rejected them, but he repeatedly declared his willingness to adopt them if new and stronger evidence in their favour could be produced. Some of his criticisms of Lavoisier's experiments had a real foundation and value. Priestley has been largely misjudged because, in spite of the simplicity of his style, he is not easy to read; his nomenclature, except in his latest years, is entirely different from ours. Sir Philip Hartog paid tribute to a transparently honest and lovable man who was a glory not only to British science, but to British manhood.

Prof. A. N. Meldrum divided his paper into two parts. In the first he showed that Priestley, by his work on gases, made a contribution to science that is unique. In the second he described Priestley's work on nitrogen peroxide. He first discussed two problems which arose in the seventeenth century and were pursued in the eighteenth century by Hales, Black, and Cavendish: the absorption and production of air in general, and the existence of gases distinct from air and from one another. Priestley, who was self-trained in experi-mental science, and made the remarkable admission

that his knowledge of chemistry was poor, examined the fixed air that is produced in the brewer's vat and used it for making aerated water. He studied the absorption of air by many agents, investigated inflammable air, and discovered the effect of vegetation on air which had been breathed by animals. The Council of the Royal Society awarded him the Copley medal for his memoir describing his work on gases. Priestley was unique in being the first to handle gases boldly, easily, and quickly, and in the course of his work he discovered nitrous oxide, ammonia, sulphur dioxide, oxygen, and nitrogen peroxide. Prof. Meldrum then gave an account of Priestley's work on nitric oxide, nitrogen peroxide, and nitric acid. He paid great attention to the colour of nitric acid and nitrogen peroxide, and studied the effect of heat on coloured nitric acid. He made two contributions to photochemistry, showing that green plants produce oxygen under the influence of light, and that light decomposes nitric acid vapour. In his work on nitrogen peroxide he invented the method of collecting a gas by displacement of air, and he showed that by dissolution in water nitric acid is formed. Another important discovery was the production of nitrososulphuric acid. The work showed the well-known Priestley—his ardour for discovery, the resources of his mind, his clever hands and eyes that nothing could escape.

Sir Harold Hartley said that Priestley's great service to chemistry was the extensiveness of his work which revealed to chemists the variety of substances which could exist in the gaseous state, their individuality, and the importance of the part they played in chemical reactions. It was all the more remarkable that Priestley's discoveries were made with a very limited knowledge of chemistry, without understanding their true meaning, and with the very simple tests available to him. He was quick to recognise gases he had obtained previously, and he had a flair for finding out the simplest methods of preparing them. Sir Harold Hartley described Priestley's discovery of the effect of vegetation on the composition of the atmosphere and that of oxygen, which he at first mistook for nitrous oxide. While Priestley failed to grasp the inner significance of his discovery, he at once saw its practical applications, suggesting its use for obtaining high temperatures and in medicine. Another side of Priestley's work reveals him as one of the earliest physical chemists. He determined the relative density of gases, examined the combination of gases by volume, determined solubility and used it as a means of identification, measured coefficients of expansion by heat, compared conductivities of sound and of heat, was the first photochemist, performed experiments with electricity, and studied diffusion, establishing its irreversibility. These physical measurements illustrate his courage and initiative as an experimenter. The secret of Priestley's genius as an investigator was his enthusiastic energy and curiosity, his fertility of mind, and the ingenuity and enterprise with which he devised new experiments with the simplest means, his keen observation, his exceptional visual memory, and the rapidity with which he could develop a new investigation. Behind this was the impelling force of his love for science, his devotion to experiment, and his boundless faith in the possibilities of new scientific discoveries.

After the discourses Dr. Alexander Scott referred to some experiences of William Russell, a friend of Priestley. Prof. H. E. Armstrong, recalling the large proportion of time which Priestley devoted to public service, said that the present times needed a like devotion.

Dr. J. Newton Friend showed a number of lantern slides illustrating geographically phases of Priestley's life.

Mr. W. C. Priestley commented briefly and appreciatively on the tribute to his famous ancestor, and gave additional information regarding his birthplace.

The president expressed the thanks of the meeting for the discourses and contributions, and remarked that by its institution of Priestley Memorial Lectures Birmingham had made some amends for its treatment of Priestley.

CORRESPONDENCE

EFFECT OF NITROGEN IN COMBUSTION PROCESSES

Sir,—Between the years 1909 and 1912, at Leeds University, Bone (Wm. A.), Gray (H. H.), and Dawson (J. B.) succeeded in displaying to their own uninterested eyes the fact that nitrogen slows down in an altogether unwarrantable manner the rate of attainment of maximum pressure in gaseous mixtures, especially mixtures containing carbon monoxide. A partial account of this work was published in the Philosophical Transactions of the Royal Society with other work done at Leeds and although I took quite an interesting share in the hard work of the research (being on the teaching staff of the University at the time) I am distinctly pleased to be able to stand aside and criticize developments independently since, in writing up the account of our three years' work, none of my ideas was represented and I am most surprised to know that publication had even been contemplated. Still, some blessings are most effectively disguised at the time and it was with an admiration not quite free from haunting doubt that I read in your columns of the truly ingenious explanation put forward by Bone and his Imperial College co-workers for the Leeds experiments. Having done the experiments at Leeds myself and having smelled oxides of nitrogen many times during the operation of preparing a morning cup of tea in the confined space of a modern scullery, I was not at all impressed with an argument that started from the inertness of nitrogen under the exciting conditions of the high-pressure explosion. Frankly it was too good to be true and one had an uneasy picture of the hen and the egg arguing together as to which came on earth first. As my own work with Dr. Thompson developed it became clear that nitrogen had not deserved its reputation for phlegm.

The use of Langmuir's name on isosteric matters made one pause, since anybody who could develop the octet in the masterly manner adopted by Langmuir is not to be dismissed without thorough examination, though no teacher who is worth his salt ever encourages idolatry. Curiously enough, however, I had occasion to re-read the other day an early but excellent summary of Langmuir's classic, and I was amazed to find how completely I had failed to grasp the importance of the

list of isosteres in connexion with the elements nitrogen and carbon. My own work had shown me pretty clearly for some years past that a reaction between nitrogen and gaseous carbon was a much more satisfactory starting point in the true explanation of the Leeds lag than was the supposition by Bone and his co-workers that nitrogen was inert. This latter fallacy has caused combustion workers and metallurgists to dwell in a fool's paradise for many years. The reports of the work of Bone and his co-workers I saw were culled from your columns and although it was made quite clear that one of the feet of the tripod was the Langmuir isosterism I never saw it stated in print that the three relevant isosteres are nitrogen, carbon monoxide, and cyanogen radicle. Of course, in this connexion I am confining my remarks to the accounts obtained from your necessarily condensed account and until I get hold of a copy of the original paper, I am unable to say whether the cyanogen radicle was mentioned or not. There is, unfortunately, in Huddersfield and towns of similar size a distinct lack of free copies of the Philosophical Transactions, and no kind friend sent me a complimentary copy. Accordingly, until I see a copy of the original Phil. Trans. paper of Bone and his co-workers I prefer to say nothing as to the eclectic nature of the isostere selection which fastened on to nitrogen and carbon monoxide, but was very severe and undeservedly rude in cutting dead poor —(CN). After all, the endothermal formation with the exothermic decomposition of cyanogen compounds (and the like) looks rather tempting as the basis of speculation for something which actually shouts for explanation and that is the startling cooling curves. Once again Mr. Editor we see how different art is from science in the relative value of eclecticism in the two branches of selection from the tree of knowledge and how thin, but Oh! how rigid must be the line which divides the artist from the artful dodger.

We can then leave the carbon monoxide side of the subject by suggesting definitely that there has been available for many years evidence that the interaction of carbon and nitrogen is likely to prove more satisfactory as an explanation of the Bone-Gray-Dawson-Leeds-Nitrogen Lag than to deny to nitrogen that birthright of every element (outside the zero group of elements) chemical reactivity. The evidence on this point is at least *pari passu*, similar to and simultaneous with the evidence for the selected cases of carbon monoxide and nitrogen.

A still more interesting point seems to be emerging with reference to hydrogen. The Leeds experiments seemed to show no interference with hydrogen but it has always seemed rather to be outstripping the constable to argue from the truly massive (even kolossal) experiments of the high-pressure laboratory to the minute refinements required of the chain reaction expert, and it is far from impossible that refined technique will show how nitrogen is not inert, even when paired off with hydrogen. The experiments of Maas and Ewing (J. Phys. Chem., 1933, 37, No. 1, pp. 13—15) clearly indicate that nitrogen is not an inert gas during the ignition (electrical) of hydrogen-air mixtures. Even isosterism fails us here! Most amusing!

We are thus forced to lean on the third leg of the Manxian tripod, which is spectroscopy under hectic conditions. One might be excused for imagining that in this case even the fowler would be scared of the net, not only the poor little dicky-birds!

I am, Sir, etc.,
H. H. Gray

Huddersfield
Apr. 10, 1933

PERSONAL AND OTHER ITEMS

Sir Thomas Lewis, M.D., F.R.S., director of the Department of Clinical Research in University College Hospital, London, has been appointed a member of the Medical Research Council in succession to Prof. J. J. R. Macleod, F.R.S., of the University of Aberdeen.

We regret to record the death, at the age of 83, of Sir Edward Rigg, who was superintendent of the operative department of the Royal Mint from 1898 to 1918. His connexion with the Mint dated back to 1873, when he was appointed assistant assayer.

Mr. Walter Chance, chairman of Chance Bros. & Co., Ltd., has been appointed to the position of president of the Birmingham Chamber of Commerce.

We regret to learn of the death at the age of 69 of Mr. Francis W. Keen, joint managing director of Guest, Keen, & Nettlefold, Ltd., and director of Bayliss Jones and Bayliss, Ltd., and other companies. Mr. Keen was a member of the Institution of Mechanical Engineers and the Iron and Steel Institute.

Mr. B. H. Soulsby, formerly librarian of the British Museum (Natural History), who left estate of the gross value £14,414, left the greater part of his property, after making bequests of books and manuscripts, to Corpus Christi College, Oxford, for research scholarships.

We regret to learn of the death of Mr. Henry Wilson, a former director of Wilsons and Mathiesons, Ltd., of Leeds, one of the largest gas apparatus producing firms in this country. It is believed that Mr. Wilson was the inventor of the gas fire about fifty years ago. He was for many years a member of the Leeds Chamber of Commerce.

Mr. Samuel Nicholls, governing director of Nicholls & Clarke, glass, lead, and paint merchants, left estate of gross value £183,583, with net personalty £176,724.

Food Group

The annual general meeting of the Food Group will be held in the London School of Hygiene and Tropical Medicine at 5 p.m. on Friday, May 26, and not on May 24 as printed in the syllabus. The occasion will also form a joint meeting with the Society of Medical Officers of Health, Metropolitan Branch, when Dr. Haldin-Davis will read a paper on "The Prevention of Industrial Diseases of the Skin."

Award of Melchett Medal

The Council of the Institute of Fuel has decided to award the Melchett Medal for 1933 to Sir John Cadman, G.C.M.G., D.Sc. The medal, which was founded by Lord Melchett, the Institute's first president, is awarded annually in recognition of outstanding work connected

with the use of fuel, and on the three previous occasions it has been awarded it has been presented to Dr. Kurt Rümmel, Prof. W. A. Bone, F.R.S., and Mr. Charles M. Schwab. Sir John Cadman, who is chairman of the Anglo-Persian Oil Co. and the Iraq Petroleum Co., and a director of many other companies, has had a very distinguished career, during which he has been president of the Institution of Mining Engineers and the Institute of Petroleum Technologists, has served the Government in many advisory capacities, and for the last twelve years has been a member of the Council of the Department of Scientific and Industrial Research and of the Fuel Research Board. He was recently awarded the gold medal of the Institution of Mining and Metallurgy.

Institute of Metals

The May Lecture of the Institute is to be delivered by Monsieur Albert M. Portevin, the distinguished French engineer and president of the Société des Ingénieurs Civils de France, at 8 p.m. on Wednesday, May 10, by kind permission, at the Institution of Mechanical Engineers. The subject of the lecture will be "Quenching and Tempering Phenomena in Alloys."

A few invitations have been placed at the disposal of the Society and members wishing to attend should communicate with the general secretary, S.C.I., 46, Finsbury Square, London, E.C.2.

British Standards Institution

The British Standards Institution has just published a standard specification for square mesh wire and round hole perforated plate. Two series of woven wire have been included to meet the needs of industry, the first being characterized by clear mesh sieves, the size of the aperture being expressed in inches, and the second by the number of meshes per linear inch, ranging from 100 down to 4 meshes per inch. Two series of perforated plates have been provided, a heavy series with holes from 3 in. to $\frac{1}{16}$ in. diameter, and a light series with holes from 1 in. to 0·029 in. diameter.

In consequence of the great variety of lengths and widths used in industry, it has not been found practicable to standardize overall dimensions of woven wire or perforated plates. It has also been found impracticable so far to lay down tolerances for the standard sizes of apertures either for woven wire or perforated plate. The co-operation of both manufacturers and users is invited in this matter, so that the revision of the specification in this direction may be possible after one or two years' experience has been gained.

Copies of this specification (B.S.S. No. 481–1933) can be obtained from the British Standards Institution, Publications Department, 28, Victoria Street, London, S.W.1, price 2s. 2d., post free.

British Glass Convention

The British glass industry is holding its Third Convention at Buxton this year from May 18 to 20. Sir Max Bonn, K.B.E., will preside, and there will be addresses and discussions on such questions as co-operation in industry, hours of work, recent technical developments in the glass industry, education, and research. At the official luncheon in the Palace Hotel, Buxton, on May 18, the chief guest will be the Rt. Hon. J. H. Thomas, P.C., M.P. A brochure giving full details of the programme is in preparation and can be obtained from the honorary secretary of the Convention, Mr. Geoffrey Marchand, M.A., director of the Glass Manufacturers' Federation, Norwich House, 13, Southampton Street, High Holborn, London, W.C.1.

Aslib Conference

The Association of Special Libraries and Information Bureaux (Aslib) is to hold its tenth annual conference at the Wills Hall, Bristol, during the week-end beginning Friday, September 22. Particulars may be obtained from the secretary of the Association, 16, Russell Square, London, W.C.1. The president of the Association, Sir Charles Sherrington, has agreed to accept office for another year.

German Chemical Publications

The Verlag Chemie G.m.b.H., of 3 Corneliusstrasse, Berlin, whose publications on chemical, physical, and technical subjects are well known in this country, are offering a discount of 10% on all orders received before April 30, 1933.

Fuel in Industry

The total quantity of coal used as fuel in industry in 1930 was approximately 61,500,000 t., with, in addition, 16,000,000 t. of coke, according to a survey of the 1930 census of production in the *Board of Trade Journal*. In addition 36,000,000 t. of coal were used at coke ovens and gas works, producing about 24,000,000 t. of coke. Compared with the figures obtained in 1924, those for 1930 show a decline of about 14,500,000 t. or 13% in the total consumption of coal, and 1,890,000, or 11% in that of coke. Of the total coal consumption, the coke and by-product undertakings absorbed 18·6%, with gas undertakings using 18·3%. Coal mines took 13·9%, electricity undertakings 9·1% and blast-furnaces and steel works 7·2%. The amount taken by chemicals, dyestuffs and drugs was 2·3% of the total.

With regard to electricity, the figures show that of the total quantity used in 1930, 54·3% was generated in firms' own establishments and 45·7% purchased. Factory trades relied generally on purchased supplies, but notable exceptions were the coke and by-product trades, the chemicals, dyestuffs and drugs trade, blast-furnaces and steel works, sugar and glucose works, and the paper-making trade. The greatest consumer of electricity was the coal mining industry with 22·9% of the total consumption. Blast-furnaces and steel works accounted for 8·1% of the total, whilst the chemicals, dyestuffs and drugs group was the fifth highest consumer with a consumption of 5·7% of the total.

World Production and Use of Soap

The estimated world production of soap in 1932 was 4·7 million tons, according to figures published in *Die Chemische Industrie* (Mar. 18, 1933, p. 197). Of this, 2·5 million tons was made in Europe, 1·8 million tons in America, and 300,000 tons in Asia and Africa. Almost all countries have increased their production over the pre-war level. In Russia production has been tripled, though it still represents only 2·5 kg. per head of the population. The greatest use of soap per person is in the U.S.A. (11·5 kg.), whilst England has a consumption of 9 kg. per head per annum.

COMPANY NEWS

IMPERIAL CHEMICAL INDUSTRIES, LTD.

The sixth ordinary general meeting was held on April 11. Sir Harry McGowan, K.B.E. (chairman and managing director) presided, and said :

The results of the year's trading operations shown in the annual report and accounts will, I am sure, have given you every satisfaction. 1932 in some respects was a mixed year. The storm of the economic depression continued to rage throughout the world, and we may be thankful that in these Islands we have been, as it were, within the shelter of a protected harbour. While not immune from the further fall in prices, from the further additions to the network of obstructions to international trade, or from the anxieties attendant upon the fluctuating values of national currencies, Great Britain has achieved a measure of stability in the volume of her internal trade and has also comparatively improved her position in international markets. At the cost of stoic efforts on the part of the taxpayer and patriotic sacrifice by investors in Government securities, we may be justifiably proud of our national financial position.

You will have read in the annual report of the general recovery in the volume of business in each of our eight manufacturing groups. That recovery is to be attributed in the main to an expansion of the volume of home business. It has been made possible by the more stable financial conditions provided by the abandonment of the Gold Standard and the check to indiscriminate imports arising from the imposition of a general tariff. The Board of Trade estimates that the volume of imports into the United Kingdom in 1932 showed a fall of approximately 12% upon the preceding year. On the other hand the volume of exports remained practically unchanged. This stability of British exports may be compared with the fall for Germany of 30%; and for the nine months to September of 24% for France and 21% for the United States.

The net profits of the year, after providing £1,000,000 for the Central Obsolescence and Depreciation Fund and £686,351 for Income Tax, amount to £4,729,072, showing an increase of £1,320,782, or 38% over the preceding year. 1932 being the third year of the depression, we are confident that these results are better than you could have expected. The improvement is attributable to three factors. The first is the increased volume of business arising from the tariff and monetary changes I have mentioned. The second is the realization of many administrative economies which have been put into effect, and the third is the further progress in the reduction of costs.

The company has continued its policy of fully maintaining all plants in a condition of the highest efficiency, as a normal charge against revenue. During the six years of the company's existence our total charges against revenue, on account of the maintenance of the manufacturing assets of the eight groups, has exceeded £12,000,000.

The profits of the year have been computed upon the same lines as in the past. I may repeat the statement in the annual report that they include no profit from the sale of securities or other capital assets. As is fitting in a time of depression, we have been perhaps more stringent in the scrutiny of possible liabilities, especially those in connexion with sales in countries where exchange restrictions are imposed.

We have again reviewed carefully the book value of the various manufacturing assets of the wholly-owned subsidiary companies, as a result of which we have decided, as stated in the report, to apply £3,662,404 from the Central Obsolescence and Depreciation Fund to writing off excess values of certain buildings and plants.

The directors have appropriated £500,000 of the profits to the general reserve, leaving a balance available, including £516,825 brought forward from 1931, of £4,745,897. The preference dividends were paid on the due dates and an interim ordinary dividend of 2½% on December 1 last. We now recommend a final dividend on the ordinary shares of 3½% making 6% for the year. To strengthen the Obsolescence and Depreciation Fund we have transferred £1,000,000 from the general reserve. After giving effect to these transfers and appropriations, the balance of the Central Obsolescence and Depreciation Fund in the books of I.C.I. at December 31, 1932, stands at £4,000,000, while the balance of the General Reserve is £9,500,000.

The balance of reserves in the books of the subsidiary companies for obsolescence and depreciation stood at December 31 last at £3,160,602, so that our total reserves for this purpose amount to £7,160,602. The fall in market values of our marketable and other investments amounted, at December 31, 1932, to £3,940,278. There has, therefore, been a further fall in market values during the year 1932. We have again decided not to make any change in the book value of these investments.

Our cash resources have largely increased. At December 31 the amount of cash in hand and invested in Government securities amounted to £7,076,269, or an increase of £2,853,369 over the preceding year, notwithstanding our having financed a bigger volume of trade. These investments in British Government securities have not been made because we desire to invest our money in this manner, but merely because, in present conditions, more profitable outlets in the expansion of our normal activities are not available.

I said last year that your company might anticipate few disadvantages and many advantages from the historic fiscal change which had taken place. After a year's experience of the working of the Import Duties Act, I am satisfied that this forecast has been amply justified. We know that as a direct consequence of the Act we have been encouraged to start up a number of new manufactures. In other cases we have promoted research work on new projects which would not otherwise have been started.

The Imperial Economic Conference held at Ottawa last summer is of too recent a date for any attempt to be made to estimate the results which may be expected to follow the agreements there signed. To my mind the great achievement lies in the actual conclusion of these agreements.

The three great Dominion companies in which we are largely interested, namely, Imperial Chemical Industries

of Australia and New Zealand, Canadian Industries, Ltd. (in which we are interested with Messrs. du Pont de Nemours & Co.), and African Explosives & Industries, Ltd. (in which our partners are the De Beers Consolidated Mines, Ltd.), continue to make satisfactory progress.

I myself have just returned from a visit to India, Palestine, and Egypt. In each of these countries we have wide and growing markets. They are all afflicted by the problem of the low prices of agricultural and primary commodities. There is almost world agreement upon the desirability—nay, the necessity—of raising these prices; but there is acute dispute as to the means which must be adopted. On the one hand there are the advocates of action by purely monetary means. They call it reflation; but their opponents use the word inflation. On the other hand a greater volume of opinion places more reliance upon control of the volume of production. Where numerous countries contribute to the total supply of primary commodities, this control can only be exercised, in my opinion, by means of international agreements. In face of a falling demand it is the ordinary practice of manufacturing industry to endeavour, within the limits of the information available as to current demand, to balance output with that demand. Capacity may be then available for the production of additional supplies, but is not used. The same remedy appears appropriate to primary commodities.

Chaotic conditions of competition in the world nitrogen industry continued during the first half of 1932. Following many international conferences, however, an agreement between the principal producers has been made for the fertilizer year ending June 30, 1933. In these discussions and arrangements the Chilean producers participated. Economic and financial conditions in Chile, as a result of the world depression, are extremely difficult, but I trust that a policy of mutual understanding and sympathy between the producers of synthetic and natural fertilizers will lead to a continuation of the present world arrangement, so that this important industry may work upon a satisfactory basis.

All the research laboratories of the company have been kept in full commission throughout the year, and the collaboration established between the universities and the chemical industry has continued to be of mutual advantage.

Our annual expenditure in this country on technical research exceeds £500,000. This is all charged against revenue. Its benefits are continuous. They may be summarized as more economical manufacturing processes, improved outputs, finer products, more efficient technical services to our customers and the development of new commodities. The major part of the expenditure is directed to these ends, but we do not neglect pure research in the chemical and other sciences which lie at the root of our industries.

We have participated with an important section of the white pigment industry in a company which will manufacture titaninm white. Considerable progress has been made with inventions to promote the use of our solid carbon dioxide refrigerant Drikold. In the building industry we are engaged with the British Steelwork Association in studying the incidence of new products and new methods of construction on the prospect of replacing unsuitable housing. Re-housing offers, in my opinion, one of the most promising avenues to a large-scale reduction of the unemployment which exists to-day.

The new equipment of our Metal Group has made possible the rolling of zinc on a considerable scale. A growing demand for an explosive for coal-mining which would give a bigger yield of round coal has been very successfully met by our new low-density type of explosive.

We have continued our research work on hydrogenation with marked success. Much has been written in the press on the economics of the process, particularly in comparison with low-temperature carbonization. These comments have necessarily been based only on costs etc. which I myself made public some eighteen months ago, and they clearly cannot make due allowance for the great strides we have since made. Our technical staff is still working on the direct hydrogenation of coal. We are satisfied that this is the correct policy. It does not preclude the use of tars as they become available in suitable quantity and at suitable prices. In fact we foresee a definite field for tar hydrogenation as well, which should be of great assistance to the carbonization industries. Large scale commercial development of our hydrogenation process now only waits upon progress in regard to a limited number of economic factors. When that is achieved, we shall be prepared to invest a substantial sum out of our present liquid resources upon this enterprise. I need not stress the aid to employment and the benefit to the British balance of payments which would follow its successful establishment in the country. Once a beginning has been made rapid expansion should follow.

At the moment the United States of America is in the midst of a financial crisis almost unprecedented even for that country of great financial movements. The outlook is obscure. Under the courageous and drastic leadership of President Roosevelt, energetic steps are being taken to cope with the complex aspects of the crisis. However successful these efforts may be, that country has, I believe, to face a period of liquidation, the immediate outcome of which may be, not an improvement in general world economic conditions, but an accentuation of present difficulties. The great fall in prices has depreciated or destroyed a large volume of the assets upon which her purchasing power rested. The reaction of these events and their solution upon the complex problem of international debt payment is obscure.

He moved the adoption of the report and balance sheet and the payment of the dividends mentioned above. The Marquess of Reading seconded the resolution which was carried unanimously.

The retiring directors, Lord Reading, Dr. W. H. Coates, Mr. J. Rogers, Mr. B. E. Todhunter, and Lord Weir were re-elected. The auditors were re-appointed and a vote of thanks to the chairman, directors, and staff terminated the meeting.

MARKET REPORT

This Market Report is compiled from special information received from the manufacturers concerned.

Unless otherwise stated, the prices quoted below cover fair quantities net and naked at sellers' works.

The following alterations in prices are reported since the publication of the last Market Report (cf. CHEM. & IND., April 7, 1933, p. 311).

GENERAL HEAVY CHEMICALS

Acid, Nitric 80° Tw.—Spot, £18–£25 per ton makers' works, according to district and quality.

Calcium Chloride, Solid, 70/75%.—Spot, £5 5s. per ton d/d station in drums.

Soda Ash, 58° E.—Spot, £5 17s. 6d. per ton, f.o.r. in bags, special terms for contracts.

Soda, Caustic, solid 76/77° E.—Spot, £14 5s. per ton d/d station in drums, special terms for contracts.

RUBBER CHEMICALS

Lithopone, 30%.—£17 10s.–£18 per ton.

Sulphur.—£11 15s. per ton. Sulphur Precip. B.P. £55–£60 per ton. Sulphur Precip. Comm.—£50–£55 per ton.

Zinc Sulphide.—1s.–1s. 1d. per lb., according to quality.

PHARMACEUTICAL AND PHOTOGRAPHIC MATERIALS

Acid, Tartaric.—11¾d. per lb. Less 5%.

Menthol, A.B.R., recryst., B.P., 15s. per lb. net. Synthetic, 8s. 6d.–12s. per lb. Synthetic detached crystals, 8s. 6d.–10s. 6d. per lb., according to quantity. Liquid (95%), 8s. 6d. per lb.

PERFUMERY CHEMICALS

Rhodinol.—60s. per lb. Safrol.—1s. 6d. per lb. Terpeneol.—2s. per lb. Vanillin (*ex Clove Oil*).—16s.—18s. per lb.—(*ex Guaiacol*)—14s. 3d.–16s. 3d. per lb.

ESSENTIAL OILS

Almond.—Foreign S.P.A., 9s. 6d. per lb. Anise.—2s. per lb. Araucaria, 9s. per lb. Bergamot.—6s. 6d. per lb. Bourbon Geranium, 26s. per lb.

Citronella Oil, Java, 2s. 9d. per lb. Ceylon, 2s. 4d. per lb. Clove.—90/92% English, 5s. per lb.

Eucalyptus, Australian B.P., 70/75%.—1s. per lb. Lavender.—Mont Blanc, 38/40%.—10s. per lb. Lemon.—4s. 3d. per lb. Lemongrass.—3s. per lb. Orange, Sweet.—6s. per lb. Otto of Rose.—Anatolian, 37s. 6d. per oz.; Bulgarian, 55s. per oz. Palma Rosa, 9s. 6d. per lb.

INTERMEDIATES

Items marked thus * d/d buyers' works.

Dichloraniline.—2s. 3d. per lb.

Dinitrobenzene.—8d. per lb.

Dinitrotoluene 48/50° C.—8d. per lb. 66/68° C.—8¾d. per lb.

**p*-Nitraniline.—Spot, 1s. 8d.–2s. 1d. per lb.

m-Xylidine acetate, 3s. 4d. per lb., 100%.

GENERAL NOTES

Official Trade Intelligence

The Department of Overseas Trade (Development and Intelligence), 35, Old Queen Street, London, S.W.1, has received the following inquiries for British goods. British firms may obtain further information by applying to the Department and stating the specific number. *Brazil:* Tinplate, linseed oil (553). *Canada:* Two *centrifugal pumps* (G.X. 12,463). *France:* Indust[...] heating apparatus, apparatus for heating industr[...] *ovens of all industries, electrical ovens for manufactu[...] of iron and steel, electrical ovens for the thermic trea[...]ment of iron and steel* (534). *Italy:* Chemical an[...] pharmaceutical products (540). *Lithuania:* Iron an[...] steel, light alloys for structural purposes (541).

Dyestuffs (Import Regulation) Act, 1920

The following statement relating to applications f[...] licences under the Dyestuffs (Import Regulation) Ac[...] 1920, made during March, has been furnished to th[...] Board of Trade by the Dyestuffs Advisory Licensin[...] Committee. The total number of applications receive[...] during the month was 650, of which 580 were fro[...] merchants or importers. To these should be adde[...] 3 cases outstanding on February 28, making a total f[...] the month of 653. These were dealt with as follows[...] Granted 631 (of which 628 were dealt with within 7 day[...] of receipt); referred to British makers of similar pro[...]ducts 12 (of which 10 were dealt with within 7 days [...] receipt); outstanding on March 31, 10. Of the tot[...] of 653 applications received, 638 or 98% were dealt wit[...] within 7 days of receipt.

Import Duties Advisory Committee

The committee has before it applications f[...] increasing the present rate of duty on hollow-ware [...] iron and steel and for extending it to other classes [...] vitreous enamelled products of iron and steel, includin[...] hospital goods, hearth plates, electric light fitting[...] refrigerator cabinets and parts, and sheets and plat[...] for advertisement signs.

Any representations in regard to changes in the rat[...] of duty should be addressed in writing to the secretar[...] Import Duties Advisory Committee, Caxton Hous[...] Tothill Street, London, S.W.1, not later than May [...] next.

PUBLICATIONS RECEIVED

SHELLAC DRYING OIL COMBINATIONS. By R. W. Aldi[...] Ph.D. Bulletin No. 12. Pp. 4. Calcutta: India[...] Lac Research Institute, 1933. Rs. 1/8.

THIRTIETH ANNUAL REPORT OF THE BUREAU OF SCIENC[...] PHILIPPINE ISLANDS. By W. H. Brown. For the Yea[...] ending December, 1931. Pp. 1025–1116a. Manila[...] Bureau of Printing, 1932.

MITGLIEDER-VERZEICHNIS DER DEUTSCHEN CHEMISCHE[...] GESELLSCHAFT, January, 1933. Pp. 109.

SCIENCE AND PRACTICE OF PHARMACY. By R. R. Bennett[...] B.Sc., F.I.C., and T. Tusting Cocking, F.I.C. Vol. I[...] Pp. viii + 385. Vol. II. Pp. viii + 339. London[...] J. & A. Churchill, 1933. 18s. each vol.

BERICHTE DER GESELLSCHAFT FÜR KOHLENTECHNIK[...] Edited by the Gesellschaft für Kohlentechnik m.b.H[...] Vol. 4, Part 2. Fourteen years' work of the Gesel[...]schaft für Kohlentechnik (1918–1932).

REPORT ON THE WORKING OF THE WATER ANALYSI[...] LABORATORY, KILPAUK, FOR THE YEAR 1931. Corpora[...]tion of Madras. Health Department. Pp. 6[...] Madras: Thompson & Co., 1932.

ANHYDRITE IN CANADA: OCCURRENCE, PROPERTIES, AN[...] UTILIZATION. By L. H. Cole and R. A. Rogers[...] Canada Department of Mines. Mines Branch. No[...] 732. Pp. v + 89. Ottawa: F. A. Acland, 1933. 20 c[...]